# Transfer of Training and Generalization: Literature Review

by:

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# Abstract

Understanding how best to train CF personnel to work effectively in teams, and how maximize their ability to use their training within new and unexpected situations is a critical requirement. This report examines the transfer literature in the psychology and team domain in order to identify the factors most likely to influence transfer performance. Research relevant to two overlapping areas of research is reviewed in this report.

First, cognitive psychological research exploring analogical reasoning casts transfer primarily as a cognitive process involving analogical reasoning, and includes encoding, inference, mapping, application and response. Established researchers in this area suggest that analogical transfer can be very powerful when it occurs, but transfer can also be a very elusive event.

The second line of research explored team transfer and team adaptation research. Team adaptation is defined as a change in team performance as the result of a salient cue that leads to some sort of response. Team adaptation could result in new structures or the modification of existing structures, abilities, and/or behaviours or cognitions directed at specific goals. This formation or manipulation of existing structures within a task (such as a cognitive schema or inter-member communication) improves how the team operates and/or achieves objectives. However, this area of research is particularly underdeveloped in the link to the most critical form of transfer in real-world environments, transfer in more complex environments and more difficult tasks.

Nonetheless, the studies reviewed provide a number of insights about the nature of transfer within teams. They show the importance of comparison processes as a positive influence on all forms of transfer (analogical, workplace and within the team context). Although comparison of stimuli and situations is relevant in the team literature, another particularly important form of comparison within a team context is comparison of one's own roles and responsibilities to those of other teammates. There is also good evidence that the transfer of the strategies learned and/or knowledge gained in this comparison process is facilitated by the emergence of a more unified body of knowledge (i.e., a mental model) that serves as an analogy, allowing the transfer of strategies and skills to a new situation to be more effective.

Overall, the literature reviewed suggested that people working to understand or promote transfer should consider multiple transfer strategies in combination. From a pragmatic perspective, this means that the design of training, the complex environment within which training occurs, and characteristics of the individual will all need to be necessary parts of CF trainers' efforts to promote transfer within CF teams.



# Résumé

Il est essentiel de trouver la meilleure manière d'enseigner aux militaires comment travailler efficacement en équipe et mettre en pratique ce qu'ils ont appris dans des situations nouvelles et imprévues. Dans le présent rapport, nous tentons de découvrir les facteurs les plus susceptibles d'influencer l'efficacité du transfert de formation à partir des ouvrages que nous avons consultés dans les domaines de la psychologie et du travail d'équipe. Nous nous penchons en outre sur des études menées dans deux domaines de recherche qui se chevauchent.

D'abord, nous nous sommes intéressés à la recherche menée dans le domaine de la psychologie cognitive sur le raisonnement analogique. Sous cet aspect, le transfert de formation est considéré surtout comme un processus cognitif faisant appel au raisonnement analogique, qui comprend l'encodage, les inférences, la mise en correspondance, la mise en application et la réponse. Selon des chercheurs reconnus dans ce domaine, le transfert analogique peut être un processus très efficace, mais il peut aussi être difficile à cerner.

Dans un deuxième temps, nous avons étudié les recherches en matière d'adaptation et de transfert collectifs. L'adaptation collective se définit comme une modification du rendement d'une équipe résultant d'une circonstance évidente suscitant une réaction quelconque. L'adaptation collective peut provoquer la création de nouvelles structures ou la modification de structures, habiletés, comportements ou connaissances déjà en place dans le but d'atteindre des objectifs précis. La formation de structures ou la manipulation de structures déjà en place à une fin précise (par exemple, établissement d'un schéma cognitif ou d'une structure de communication intraorganisationnelle) augmente l'efficacité d'une équipe et l'aide à atteindre les objectifs qu'elle s'est fixés. Ce domaine de recherche demeure toutefois peu exploré, surtout en ce qui concerne la plus importante forme de transfert, soit celle qui vise à appliquer les connaissances acquises à des situations réelles afin de résoudre des problèmes plus complexes.

Néanmoins, les études sur lesquelles nous nous sommes penchés offrent un aperçu de la façon dont se passe le transfert d'acquis de formation au sein d'une équipe. Elles montrent l'importance des processus de comparaison et de leurs effets positifs sur tous les types de transfert (analogique, en milieu de travail et au sein d'une équipe). Bien que la comparaison des stimuli et des situations soit un aspect pertinent dans le domaine du transfert collectif, la comparaison des responsabilités entre les membres d'une équipe revêt également une importance particulière. Ce type de comparaison est au cœur de nombreuses formes de formation collective. De plus, tout porte à croire que le transfert des stratégies et des connaissances acquises durant le processus de comparaison est facilité par l'émergence d'un ensemble de connaissances plus uniforme (c.-à.-d., un schème de pensée) permettant l'expression d'une analogie et, par le fait même, l'adaptation de stratégies et de connaissances à une nouvelle situation de manière à accroître l'efficacité collective.

Dans l'ensemble, les ouvrages consultés indiquent que les gens souhaitant mieux comprendre ou favoriser le transfert d'acquis devraient envisager d'avoir recours à différentes stratégies à la fois. D'un point de vue pragmatique, cela implique que les instructeurs des FC devront tenir compte de la conception de la formation elle-même, de la complexité de l'environnement dans lequel la formation est donnée ainsi que des caractéristiques individuelles des personnes concernées afin de maximiser l'efficacité du transfert des acquis de formation au sein de leurs équipes.



# **Executive Summary**

## **Transfer of Training: Literature Review**

#### Michael H. Thomson, Courtney D. Hall, Craig R. Flear, Cheryl L.F. Karthaus, Barb D. Adams, Human*systems* Incorporated; DRDC Toronto No. CR2012-064; Defence R&D Canada – Toronto; April 2012.

The Canadian Forces (CF) current and future operations will likely include mission types covering the Adaptive Dispersed Operations (ADO) mission spectrum, ranging from humanitarian missions to combat operations. CF personnel can sometimes only participate in a limited amount of training before deployment. As training is time consuming and expensive, preparing for every situation that can arise in theatre is impossible. Generalizing the skills learned in training to real world challenges is critical. Understanding how best to train CF personnel to work effectively in teams, and how to maximize their ability to use their training within new and unexpected situations is a critical requirement. This report examines the transfer literature in the psychology and team domain in order to identify the factors most likely to influence transfer performance. Research relevant to two overlapping areas of research is reviewed in this report.

First, cognitive psychological research exploring analogical reasoning is explored. Conceived from this perspective, transfer is understood primarily as a cognitive process involving analogical reasoning, and includes encoding, inference, mapping, application and response. Established researchers in this area suggest that analogical transfer can be very powerful when it occurs, but transfer can also be a very elusive event. Literature reviewed in this chapter shows that when in a new situation, people often fail to access information they have available to them from their previous experiences For example, people seem to have trouble solving a problem that is analogous to one already (and recently) solved, when the problem is similar but comes from a different context. Nonetheless, relying on explicit comparison and using these principles can promote analogical transfer.

The second line of research explored team transfer and team adaptation research. Team adaptation is defined as a change team performance as the result of a salient cue that leads to some sort of response. Team adaptation could result in new structures or the modification of existing structures, abilities, and/or behaviours or cognitions directed at specific goals. This formation or manipulation of existing structures within a task (such as a cognitive schema or inter-member communication) improves how the team operates and/or achieves objectives. The team studies reviewed in this section provide a number of insights about the nature of transfer within teams. They show the importance of comparison processes as a positive influence on analogical transfer. Although comparison of stimuli and situations is relevant in the team literature, another particularly important form of comparison within a team context is comparison of one's own roles and responsibilities to those of other teammates. This sort of comparison process is at the core of many relevant forms of team training. There is also good evidence that the transfer of the strategies learned and/or knowledge gained in this comparison process is facilitated by the emergence of a more unified body of knowledge (i.e., a mental model) that serves as an analogy, allowing the transfer of strategies and skills to a new situation to be more effective. However, this area of research is particularly underdeveloped in the link to the most critical form of transfer in real-world environments, namely transfer in more complex environments and more difficult tasks.



Despite the lack of clarity in the research literature, it is also clear that trainers and researchers will still need to make the best of the information that is available about transfer, leaving prominent researchers to argue that "...the roughly equivalent predictive power of several individual and situational predictors reflects the reality that there are no magic bullets for leveraging transfer." Blume et al. (2010, p. 1096). This means that people working to understand or promote transfer should consider multiple transfer strategies in combination. From a pragmatic perspective, this means that the design of training, the complex environment within which training occurs, and characteristics of the individual will all need to be necessary parts of CF trainers' efforts to promote transfer within CF teams.



# Sommaire

# Le transfert des acquis de formation: analyse bibliographique

#### Michael H. Thomson, Courtney D. Hall, Craig R. Flear, Cheryl L.F. Karthaus, Barb D. Adams, Human*systems* Incorporated; DRDC Toronto No. CR2012-064; R&D pour la defense Canada – Toronto; Avril 2012.

Les Forces canadiennes (FC) seront vraisemblablement appelées à mener des missions de plus en plus variées couvrant l'ensemble du spectre des opérations adaptables et dispersées (OAD) [missions humanitaires, opérations de combat, etc.]. Les membres des FC disposent souvent d'un temps limité pour la formation avant un déploiement. Comme la formation est une activité qui nécessite beaucoup de temps et d'argent, il est impossible de préparer les soldats à toutes les situations pouvant se produire durant une opération. Il est primordial de faire en sorte que ces derniers soient en mesure d'appliquer les connaissances et les habiletés générales qu'ils ont acquises durant leur formation dans des situations réelles. Il est donc essentiel de trouver la meilleure manière d'enseigner aux militaires comment travailler efficacement en équipe et mettre en pratique ce qu'ils ont appris dans des situations nouvelles et imprévues. Dans le présent rapport, nous tentons de découvrir les facteurs les plus susceptibles d'influencer l'efficacité du transfert de formation à partir des ouvrages que nous avons consultés dans les domaines de la psychologie et du travail d'équipe. Nous nous penchons en outre sur des études menées dans deux domaines de recherche qui se chevauchent.

D'abord, nous nous sommes intéressés à la recherche menée dans le domaine de la psychologie cognitive sur le raisonnement analogique. Sous cet aspect, le transfert de formation est considéré surtout comme un processus cognitif faisant appel au raisonnement analogique, qui comprend l'encodage, les inférences, la mise en correspondance, la mise en application et la réponse. Selon des chercheurs reconnus dans ce domaine, le transfert analogique peut être un processus très efficace, mais il peut aussi être difficile à cerner. Dans les ouvrages que nous avons consultés, il est démontré que lorsqu'ils se trouvent dans une situation nouvelle, les gens ont souvent tendance à ne pas utiliser les connaissances qu'ils ont acquises lors d'expériences antérieures. Par exemple, les gens semblent avoir de la difficulté à résoudre un problème analogue à un autre qu'ils ont déjà résolu par le passé (même récemment) lorsque les problèmes en questions sont similaires, mais abordés dans des contextes différents. Néanmoins, on peut créer les conditions propices au transfert analogique en établissant des comparaisons explicites et en mettant en pratique les principes susmentionnés.

Dans un deuxième temps, nous avons étudié les recherches en matière d'adaptation et de transfert collectifs. L'adaptation collective se définit comme une modification du rendement d'une équipe résultant d'une circonstance évidente suscitant une réaction quelconque. L'adaptation collective peut provoquer la création de nouvelles structures ou la modification de structures, habiletés, comportements ou connaissances déjà en place dans le but d'atteindre des objectifs précis. La formation de structures ou la manipulation de structures déjà en place à une fin précise (par exemple, établissement d'un schéma cognitif ou d'une structure de communication intraorganisationnelle) augmente l'efficacité d'une équipe et l'aide à atteindre les objectifs qu'elle s'est fixés. Les études sur lesquelles nous nous sommes penchés offrent un aperçu de la façon dont se passe le transfert d'acquis de formation au sein d'une équipe. Elles montrent l'importance des



processus de comparaison et de leurs effets positifs sur le transfert analogique. Bien que la comparaison des stimuli et des situations soit un aspect pertinent dans le domaine du transfert collectif, la comparaison des responsabilités entre les membres d'une équipe revêt également une importance particulière. Ce type de comparaison est au cœur de nombreuses formes de formation collective. De plus, tout porte à croire que le transfert des stratégies et des connaissances acquises durant le processus de comparaison est facilité par l'émergence d'un ensemble de connaissances plus uniforme (c.-à.-d., un schème de pensée) permettant l'expression d'une analogie et, par le fait même, l'adaptation de stratégies et de connaissances à une nouvelle situation de manière à accroître l'efficacité collective. Ce domaine de recherche demeure toutefois peu exploré, surtout en ce qui concerne la plus importante forme de transfert, soit celle qui vise à appliquer les connaissances acquises à des situations réelles afin de résoudre des problèmes plus complexes.

Malgré le fait qu'il reste beaucoup à apprendre sur le transfert d'acquis de formation, les instructeurs et les chercheurs devront continuer de se contenter de l'information à laquelle ils ont accès et d'en tirer ce qu'ils peuvent. Cela amène les chercheurs à penser que « [...] le pouvoir prédictif quasi équivalent des différents indices individuels et contextuels montre qu'il n'existe pas de formule magique pour optimiser le transfert d'acquis » (Blume et coll., 2010, p. 1096). Cela signifie que les gens souhaitant mieux comprendre ou favoriser le transfert d'acquis devraient envisager d'avoir recours à différentes stratégies à la fois. D'un point de vue pragmatique, cela implique que les instructeurs des FC devront tenir compte de la conception de la formation elle-même, de la complexité de l'environnement dans lequel la formation est donnée ainsi que des caractéristiques individuelles des personnes concernées afin de maximiser l'efficacité du transfert des acquis de formation au sein de leurs équipes.



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# 1 Introduction

### 1.1 Background

The Canadian Forces (CF) current and future operations will likely include mission types covering the Adaptive Dispersed Operations (ADO) mission spectrum. On one end of the ADO spectrum are humanitarian missions, including aid distribution and nation building. On the other end of the spectrum are combat missions, including kinetic engagements and security. Because these missions require various skills and adaptation, The Land Operations 2021: Adaptive Dispersed Operations has recommended that CF personnel have a "sufficiently broad spectrum of personal competencies" (Land Operations 2021: Adaptive Dispersed Operations). Likewise, the Director of Land Concepts and Development has identified the notion of agility for team effectiveness as an area for future research. To this end, the current project will examine training methods and the effectiveness of those methods on transferring the knowledge and skills developed during training to a range of tasks.

The training methods used to teach the skills require three components for effectiveness in ADO missions. First, the training is not effective unless trainees can transfer the skills taught in training to theatre. Second, generalizing the skills learned in training to new situations may increase effectiveness in ADO missions. Last, adapting to the changes of the mission shows the agility of the skills learned and ability to maintain effectiveness.

In the SOW (Statement of Work), the transfer of skills can be considered a direct application of the skills taught in training to the skills used in theatre. Training can occur in a classroom setting (e.g., at the Royal Military College of Canada), or in a field setting (e.g., Peace Support Training Centre). The skills that are taught in either situation can then be transferred to theatre. For example, personnel at the Peace Support Training Centre are taught how to perform first aid. These skills are then transferred in theatre when first aid is needed. Although the training may not specifically cover the event in theatre, the same basic first aid applications can be used. In the training of skills, it is not always possible to cover the situations encountered in theatre thus, the generalization of skills is important.

As training is time consuming and expensive, preparing for every situation that can arise in theatre is impossible. Moreover, CF personnel can sometimes only participate in a limited amount of training before deployment. To this end, generalizing the skills learned in training is critical. Generalization of skills can be considered the use of trained skills in new situations. For example, learning the skills in convoy operations can be generalized to counter-improvised explosive device situations (e.g., examining the terrain for anything out of the ordinary). Although personnel are capable of generalizing their skills learned in training to new situations, what happens when those situations suddenly change?

Adapting to changes in the mission may be difficult to many personnel, especially when team members must fill difficult roles and duties. Developing the skills needed to fulfil specific roles and duties is only half the battle. Understanding when to switch roles and duties to adapt to the situation at hand can be challenging. Sometimes one team is required to perform multiple missions. These team members are required to identify when to switch roles with another team member. For example, if the designated team leader is not performing their duties satisfactorily, other team members should be able to step in and assist the leader in accomplishing the tasks. This action



would require the knowledge of the roles, the ability to identify when the role is not being filled properly, and the agility skills to change from the current role to the role that needs to be filled.

Thus, there is a need for the CF to be trained on specific skills and to use these skills effectively in theatre. This project is intended to highlight the factors that promote transfer of training, generalization of skills, and team adaptation. The majority of the research on the transfer and generalization of skills is from psychology literature, and typically focuses on the individual rather than at the team level. However, the CF typically works in teams. This paper will attempt to link the factors relevant in the psychology literature to the factors found in the team literature. This will allow the previous research to be applied to a team setting. Specific factors likely to influence transfer, generalization and adaptation are the methods in which skills are trained, the methods in which transfer is evaluated, the similarities and differences between training tasks and transfer tasks, and the factors that promote transfer can provide the CF with the knowledge of what training methods are working and what needs to be improved.

Education and training are meant to provide students/trainees with learning experiences that promote the further exercise of knowledge, skills and information developed in training to new situations. For example, teaching formal logic in the classroom is meant to develop deductive reasoning skills, so that students can generalize the rules of logic they learned in a particular learning context to real life decision making contexts. Or alternately training soldiers how to properly fire a C7A2 Rifle may provide enough knowledge and skill of basic small arms weapon systems so that they can also fire a C8 Carbine (or C7CT/AR-10T Marksman Rifle), given the similarity of rifle systems' design and function. In both cases, the underlying goal of the education and training is to ensure the transfer of newly acquired knowledge, skills and information from the learning situation to a new situation can occur. Indeed, as Brown (1989, p. 369, cited in Barnett & Ceci, 2002) explains, "[f]lexible use of knowledge is often cited as the hallmark of human intelligence". The goal of this review, then, is to elaborate on research and relevant literature exploring how newly acquired information and skills is transferred into new situations.

### 1.2 Purpose

The purpose of this report is to examine the transfer of training literature in the psychology and team literature in order to identify potential commonalities that might be relevant to both domains. Moreover, the literature is infused with factors that may increase transfer of training and that may, in turn, improve performance. This report will highlight these factors and link them to the team domain as being likely to be fruitful in future research exploring team adaptation and team agility.

### 1.3 Scope and Deliverables

This project had 3 phases including the following:

- Phase 1 establish key terms
- Phase 2 literature search
- Phase 3 literature review and writing report

Phase 1 involved developing a list of keywords used in searching for articles. The SA recommended that the keywords cover both the psychological domain, as well as the team domain. Details regarding development of the keywords and the keywords themselves can be found in Section 2.1.



Phase 2 included the literature search using the key terms developed in Phase 1. The research team searched only peer reviewed journals commonly recognized to be of high quality. Based on the results of the literature search, articles were categorized and assessed. Only key articles were to be included in the report, with no more than 80 articles, 40 articles in each domain. Details regarding the selection of articles can be found in Section 2.3. After Phase 2 was complete, the research team met with the SA to go over the key terms that were formulated during Phase 1 and the results of the literature search in Phase 2.

Phase 3 included the review of each article and report writing. The research team divided the literature and the report into the 2 main domains, namely psychology and team. The first part of the report was meant to be a summary and critique of the research in each domain. This summary was originally intended to highlight the factors that helped and hindered transfer of training. The second part of the report addressed factors that were common in the psychology and team literature. However, after discussion with the SA, the main focus of the report shifted slightly and explaining the construct of transfer of training, followed by an examination of the literature were identified as the highest priorities.

### 1.4 Deliverables

The following deliverables were created under this contract and presented in the Statement of Work (SOW):

- Literature review as a contractor report written according to DRDC template guidelines and APA version 5 (or above) style
- Electronic or paper copies of the all articles in the literature corpus cited in report.
- Endnote library file containing reference citations for articles in the literature corpus cited in report.



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# 2. Methods and Results

### 2.1 MindMap and Keywords

To begin, a MindMap<sup>TM</sup> was generated to provide an illustration of the major constructs and other research areas relevant to the topic of transfer of training and generalization, as well as team adaptation. This process involved a brainstorming session with all members of the research team, and relied on their cumulative knowledge and experience with the pertinent scientific, psychological, and military domains. From the MindMap, a set of keywords was developed to focus the literature search. The team established a number of core concepts, which included transfer of training, team, team process, team performance, and military, as shown in Table 1.

Core Concept	Keywords
Transfer of training	Positive transfer, negative transfer, learning transfer, process of transfer, training effectiveness, generalization, training outcomes, transfer behaviour, learning application, application of training, transfer performance, expected utility
Trainee characteristics	Cognitive skills, problem-solving, analogy, judgement/decision-making, knowledge, memory, retention, procedural/declarative, long-term, short-term, attitudes, motivation, personality, locus of control, need for achievement, anxiety, trainability, conscientiousness, goal orientation, motivation to transfer, reaction to training
Team characteristics	Leader, size, history, task factors, task complexity, workload, task type
Work environment characteristics	Opportunity to transfer, transfer climate, intervention strategies, peer support, organizational performance
Team process	Communication, coordination, collaboration, cooperation, interdependence, integrative, interaction, connectivity, adaptability, adaptation, planning, workload, team climate, mental models
Team outcomes	Shared mental model, team mental model, shared situation awareness, shared knowledge, shared cognition, team cognition, common intent, common ground, team effectiveness, team performance, post-training self-efficacy, reaction to training, declarative knowledge, skill acquisition
Training approach/design	Cross training, coordination and adaptation training, generic skills, core skills, key skills, common skills, key competencies, essential skills, transferable skills, key qualifications
Military	Army, Navy, Air Force, Canadian Forces, rules of engagement, tactical, operational, strategic, soldier, war, doctrine

Table	1.	Keywords
IUNIC		1109110100

After establishing the core concepts, primary keywords were then developed, as shown in the second column of Table 2. The latter terms were the most important words used in the search as they represented the broad constructs relevant to research regarding the impact of transfer of training on generalization and team adaptation. The primary keywords ensured sampling of literature from several different domains within the core construct, and their use was guided by what emerged from the core concepts. For example, for the core concept of "transfer of training", primary keywords such as "generalization", "performance", "learning", and "education" emerged



as the most critical. The purpose of the primary keywords was to ensure that those aspects particular to the topic at hand were tapped (e.g. "generalization") and those not relevant to the topic at hand were discounted (e.g. "education"). Related keywords provided a further layer of detail to the core concept, and they were used in conjunction with the core concept and primary keywords. This had the result of narrowing the search to the most relevant articles.

### 2.2 Databases

The following primary databases were the most relevant for searching the scientific, psychological, and military domains.

Database	Description
PsycINFO	The PsycINFO database is a collection of electronically stored bibliographic references, often with abstracts or summaries, to psychological literature from the 1800s to the present. The available literature includes material published in 50 countries, but is all presented in English. Books and chapters published worldwide are also covered in the database, as well as technical reports and dissertations from the last several decades.
NTIS	National Technical Information Service is an agency of the U.S. Department of Commerce's Technology Administration. It is the official source for government sponsored U.S. and worldwide scientific, technical, engineering, and business related information. The database contains almost three million titles, including 370,000 technical reports from U.S. government research. The information in the database is gathered from U.S. government agencies and government agencies of countries around the world.
CISTI	Canada Institute for Scientific and Technical Information houses a comprehensive collection of publications in science, technology, and medicine. It contains over 50,000 serial titles and 600,000 books, reports, and conference proceedings from around the world.
Public STINET	Public STINET is available to the public, free of charge. It provides access to citations of unclassified unlimited documents that have been entered into DTIC's Technical Reports Collection, as well as the electronic full-text of many of these documents. Public STINET also provides access to the Air University Library Index to Military Periodicals, Staff College Automated Military Periodical Index, DoD Index to Specifications and Standards, and Research and Development Descriptive Summaries.
WWW	World Wide Web

Table 2. Primary databases for scientific/academic search

### 2.3 Selection of Articles

The search of the databases generated more than 100 titles and abstracts. There were also approximately 30 articles that the research team already had before the search, the majority were received from the SA. The research team reviewed all the articles and ranked each (primary, secondary, or tertiary) according to its relevance. Priority was given to those articles that represented the core concepts, and higher priority was given to articles that discussed multiple core concepts than to articles that addressed only a single core concept. Once titles and abstracts were ranked according to relevance, the research team obtained as many of the primary articles as possible. Overall, the references comprised books, journal articles and technical reports from the behavioural sciences, military, and business domains.



The original primary list of articles included approximately 100 articles. A spreadsheet was created that included where each article was retrieved from, the article year, title, authors, journal, abstract, focus of the article, type of effects, variables, experimental design, results, and relevant notes. After the research team met with the SA, the focus of the project shifted from highlighting the factors that helped and hindered transfer to examining the construct of transfer of training and relevant literature. With this in mind, these 100 articles were re-assessed by the SA and 2 research team members to narrow down the list significantly. The re-assessment highlighted the core articles of the original 100 primary articles by considering the elements of the spreadsheet. The research team weeded out articles that included self report as the transfer measure and those that were less relevant. About half of the original 100 primary articles and obtained the rest of the articles from the reference lists.

### 2.4 Review of Articles

Once final articles were obtained and shared with the scientific authority, researchers began to review and write on the articles that pertained to various sections of the report. After reviewing approximately 20 articles and chapters, the research team developed a broad outline of the major issues. This outline was used to further categorize the applicability of the other articles and to focus the review of the remaining obtained articles. In all, approximately 30 primary articles were reviewed in detail with at least 50 others used as secondary readings and articles.

### 2.5 Structure of the Report

The first 2 chapters of this report introduce the topic area and describe the process of searching, filtering and reviewing articles. The third chapter explores the construct of transfer and some of the many ways in which it is defined. The fourth chapter reviews research relevant to cognitive perspectives on transfer, most often described in terms of analogical transfer. The fifth chapter explores prominent models of transfer and some alternative perspectives on it. The sixth chapter describes another body of literature exploring transfer from the training and workplace perspective. The seventh chapter reviews empirical research relevant to transfer within teams. This is preceded by a discussion about the theoretical construct of team adaptation, noted in the Statement of Work as one possible way to understand the process of transfer within teams. The final chapter explores and summarizes the findings of the review and attempts to link the different perspectives on transfer from the psychological domain (e.g., analogical reasoning), in the workplace and within the team context.

### 2.6 Limitations

This report has several key limitations that are important to note. The transfer literature is highly complex and difficult to interpret. There are many constructs in play, and little consistent use of terminology throughout the extant literature. This area of research also appears to be highly contentious, with many conflicting opinions about the very nature of transfer, as well as a wide range of inconsistent research results. This made it very difficult to get clarity about the key factors that might influence transfer and adaptation within a team domain.

We attempted to address some of the difficulties that we encountered by reviewing some of the theoretical models relevant to transfer and team adaptation. It was hoped that these models might help steer us toward key constructs that should receive specific attention. Although these efforts were helpful, they did not suggest any serious convergence on the exact nature of transfer, or



around how best to tailor our efforts, even these models reflect the core lack of agreement within the transfer literature.

The number of different literatures in play also exacerbated these difficulties to some extent. We accessed literature related to training, learning and education and team adaptation in order to ensure that there were no domains in which transfer might be better understood and articulated. Unfortunately, the lack of clarity permeated all of these literatures. The number of constructs in play also made it impossible to review all applicable empirical studies that would be necessary to reach convergence about the state of the literature with respect to a specific variable. In the end, it was not possible to consider all the research relevant to a specific construct, so we attempted to use summary and overviews of existing experts within this area of research to inform the conclusions that could be reached. To meet this challenge, we relied on meta-analyses conducted by expert researchers with a long history studying the problem of transfer (e.g., Blume, Ford, Baldwin and Huang, 2010). This allowed us to explore the impact of more variables on transfer.

Whatever challenges encountered, however, this review will hopefully provide a helpful discussion of the literature relevant to transfer in teams, and offer some insight into how transfer has been understood and researched in recent years.



# 3. The Concept of Transfer

This chapter introduces the concept of transfer and examines definitions and key topics relating to the transfer of training. Though there has been a broad range of interests into the nature of transfer, (e.g., the conditions under which transfer is facilitated or inhibited), the majority of research represents two distinct (though complementary) psychological disciplines. Through a tradition of basic research, cognitive psychology has worked to uncover the constitutive components of the transfer process and the principles overlying it. Other branches of psychology, such as Industrial/Organizational (IO) psychology have worked to understand transfer outside of the laboratory (and often within the workplace). The following sections explore the concept of transfer from each of these perspectives.

### 3.1 Cognitive Perspectives on Transfer

One prominent way of conceptualizing transfer is as a cognitive process requiring information processing (e.g., how information is processed in one situation) and including the use of analogy in order to transfer what one has learned in one context to another.

Early approaches to understanding transfer focused on the cognitive processes underlying it. Transfer studies started in the early twentieth century when psychology was under the influence of the behaviourist movement. The original conceptualization of transfer essentially consisted of uniting the features of the environment (the stimulus) with the reaction of the participant (the response), where learning consisted of making correct stimulus-response associations. One early study conducted by Edward Thorndike and Robert Woodworth (1901) required participants to judge the area of rectangles and record their judgements. Participants could refer to a piece of paper that contained three square shapes with the area of each highlighted on the piece of paper. This was used as a reference for estimating the size of the rectangles. Once participants showed an improvement in their ability to estimate the area of rectangles, they were then asked to estimate the area of circles and triangles. The ability to estimate the area of dissimilar shapes would demonstrate the generalization of skills from estimation of rectangles. However, Thorndike and Woodworth did not find any evidence that learning to estimate the area of a rectangle transferred to estimating the area of triangles and circles. This finding (and a range of other unsuccessful studies) led them to conclude that transfer rarely occurred. However, they argued that when transfer did occur, the transfer source and transfer target needed to share similar elements (known as identical elements theory). A number of additional studies adhering to the behaviourist approach of identical elements were conducted, with little evidence demonstrating transfer. Unhappy with these general outcomes, researchers studying transfer switched to a more cognitive perspective.

Cognitive perspectives on transfer were driven by the theory that "learning to solve one problem may enhance the solving of another problem depending on similarities between how the two problems are mentally represented" (Marton, 2006). It is argued that people are able to transfer learned material to a novel setting because they are able to link surface features of structurally similar problems (Marton, 2006). Cognitive and learning theorists argue that abstracting structural features is a critical part of transfer. From the cognitive perspective, focus on the structural features supplants the focus on surface features (identical elements). Hence, they shifted their attention to predicting how individuals' work to abstract information from a learning situation and transfer this to a novel situation. This process is analogical reasoning and amounts to producing analogies in a novel setting on the basis of previously learned material.



#### 3.1 The Concept of Analogical Reasoning

One of the most prominent ways of understanding transfer is as a process that is dependent on analogical learning and reasoning. As such, it is important to understand the concept of an analogy. Merriam-Webster defines analogy as:

- 1) inference that if two or more things agree with one another in some respects they will probably agree in others
- 2) resemblance in some particulars between things otherwise unlike or comparison based on such resemblance

Analogy has a prominent place in learning, and has been given a role in both critical thinking (Halpern, 1998; cited in Loewenstein, Thompson and Gentner, 2003) and in managerial problem solving (Isenberg, 1986; cited in Loewenstein et al. 2003). In its simplest form, analogy can be understood as the ability to "use a well-understood topic to make sense of new topic" (Loewenstein et al. 2003, p. 120). Gentner and colleagues have defined analogical transfer as "mapping knowledge from a prior stored situation to a current situation" (Gentner, Loewenstein, Thompson and Forbus, 2009, p. 1343). When generating an analogy, an individual can use knowledge from one domain (the source or base) and apply this knowledge to the target in another domain (Spellman & Holyoak, 1996, Clement & Gentner, 1991, both cited in Blanchette & Dunbar, 2000), as shown in Figure 1.



Figure 1. Analogical transfer

More specifically, Gentner, Rattermann, and Forbus (1993, p. 526) hold that an analogy can be defined as "a one-to-one mapping from one domain representation (the base) into another (the target) that conveys that a system of relations that holds among the base objects also holds among the target objects independently of any similarities among the objects to which those relations apply".

Source and target objects can be linked in several different ways. Blanchette and Dunbar (2000) argue that constructing an analogy requires two levels of relationships between two domains. The first level is surface similarity. According to Catrambone (2002, p. 318), surface similarity refers to "features that, when changed, do not affect the solution procedure for a problem or do not affect relationships such as causal relationships in a story". Surface similarity primarily relates to features such as object attributes. The second, and deeper form of similarity is structural similarity. Structural similarity relates to underlying principles or higher-order relationships such as causal relations, that "if changed, can affect the solution procedure or relationships" (Catrambone, 2002, p. 318). Most cognitive researchers assume that the relationships associated with structural similarity reflect the "true" nature of analogy (and hence transfer), presumably because this evidences a greater ability to abstract from one source to another source. Greater generalization across situations means greater transfer of source material to novel settings.

According to Sternberg (2000), analogical reasoning consists of five phases, including encoding (activating information in long term memory based in information received through the senses



(e.g., relevant features of the analogs) and retaining the activated elements in working memory), inference (discovering the relationships between the two concepts or analogs activated during the encoding process and retaining them in working memory), mapping (connecting the relationships between the activated concepts or analogs), application (similar to mapping), comparison or evaluation (comparing the internally generated answer to the response perceived to be most correct) and response. The next section explores transfer processes applied to the training context, from an IO perspective.

# 3.2 Industrial/Organizational Perspectives on the Transfer of Training

Perhaps the most frequently cited definition stemming from the IO psychology/teams literature was provided by Baldwin and Ford (1988) who define transfer as:

"the generalization of knowledge and skills acquired in training to the job and the maintenance and enhancement of that learning over time" (p. 64).

This definition has a number of critical elements. Transfer is conceptualized as requiring both generalization and maintenance. It is also important to explore some of the underlying logic of this definition. There is an explicit assumption that some form of learning (i.e., knowledge and skills) will first be acquired within the training environment. However, learning is distinct from transfer. For transfer to occur, this new learning must actually generalize to a different environment. Within the transfer of training literature, generalization is typically understood in relation to the actual work environment, as facilitation of job performance is the reason that training typically occurs. However, this definition does not specify exactly what generalization might mean, whether "moving over" one part of the new skill is adequate for generalization or whether true generalization requires that all aspects of the skill are transferred. This definition also gives an important role to maintenance of the skill that has been generalized to the new environment. However, there is no specification of how long this maintenance must last, other than "over time".

There is also clear dissatisfaction noted in the literature about the prevailing definitions of transfer. For example, Barnett and Ceci (2002, p. 614) note that "Although there are definitions of transfer such as "the carrying over of an act or way of acting from one performance to another" (Woodworth & Schlosberg, 1954; cited in Barnett and Ceci, 2002) and "the ability to extend what has been learned in one context to new contexts" (Bransford, Brown and Cocking, 1999; cited in Barnett and Ceci, 2002), there is no clear, agreed-upon definition of what constitutes "carrying over" or "a new context".

The concept of transfer has become increasingly multidimensional over the years. A recent review of the transfer literature since 1988 (Baldwin, Ford and Blume, 2009) noted that the 2 key dimensions of transfer (generalization and maintenance) have been extended by recent research. For example, they argue that the ability to adapt in dynamic (e.g., novel or changing) situations is another dimension that has been increasingly prominent in more recent research. There is a somewhat uneasy tension within the available literature among researchers within the cognitive tradition and those in the "workplace" tradition. For example, Baldwin and Ford (1988) seem to all but dismiss what they call "perceptual" research. "Conclusions from the existing research are problematic, given the relatively short-term, single source, perceptual database that has been created" (Baldwin and Ford, 1988, p. 100). The fact that these two literatures seem to be developing in relative isolation indicates the line between psychological research exploring transfer, and research exploring transfer of training. Another line of transfer of training research



extends beyond the cognitive perspective to the broader environment, to include the role of the individual, the task and the environment in the generalization and maintenance of skills. Each of these approaches to understanding transfer (and relevant research about them) is considered in the chapters that follow.

In addition to creating an organizing conceptual framework intended to guide future transfer of training research, Baldwin and Ford (1988) reviewed and critiqued 63 previous research efforts, concluding that "while the limited number and the fragmented nature of the studies examining transfer are disturbing by themselves, a critical review of the existing research reveals that the samples, tasks, designs, and criteria used limit even further our ability to understand the transfer process" (p. 86). To help fill in these gaps, they suggested that future research initiatives should take into account a greater variety of factors and linkages by taking "a more eclectic orientation towards transfer" (p. 98), while adopting a more interactive and dynamic perspective of the transfer process (i.e., develop and test frameworks which incorporate multiple inputs and their complex interactions, instead of testing a single input and measuring its effect in a vacuum).

A more recent effort by these authors and other colleagues has updated the literature in the period 1988 to 2008 (Baldwin, Ford and Blume, 2009). This review included more than 140 research articles and had several goals. The review aimed to identify significant conceptual and empirical advances in transfer of training research since the last transfer of training review. This review also focused on identifying important future directions for this body of research. A number of key advances in transfer of training research were noted in this review. In their 1988 review, they had noted that many studies within the domain prior to 1988 were limited to what they called "simple motor and memory tasks completed in laboratory settings with college students" (Baldwin et al., 2009, p. 43). This review identified several key areas of progression since the last 1988 review, including

- Use of more complex and authentic learning contexts
- Increased focus on transfer interventions
- Focus on pre and post-training transfer influences
- More variety in the measurement of transfer

In their 1988 review, Baldwin and Ford had lamented the artificiality and relative simplicity of the contexts in which transfer was studied. The 2009 review notes that a broader range of samples and more authentic skills have been in play more recently. However, they do note the need for increasing integration and to be able to compare across multiple studies, "...to develop categories or taxonomies of skills and contexts that can lead to cumulating results of transfer studies across different types of knowledge and skill training" (Baldwin et al., 2009, p. 44). Some evidence of increasing theoretical development is evident in more recent research, as described in the section that follows.

Nonetheless, Blume et al. (2010) argue that there is a lack of clarity in the existing literature about how transfer should be conceptualized, whether it is seen as the "use of a trained knowledge or skill" or as the "effectiveness of the trainee in applying the knowledge or skill" (p. 1072). Effectiveness represents a continuum of skill level, whereas use represents a binary yes/no decision about whether or not the skill was displayed. The fact that existing researchers have rarely paid attention to this distinction is a serious limitation of current research.



### 3.3 Important Theoretical Distinctions

Within the transfer literature, a current requirement is an organizing structure that will help to understand disparate results and to dimensionalize the factors at play. The beginnings of such approaches are notable contributions to the transfer of training literature.

Traditional conceptions of "transfer of training" or the "transfer of learning" hold that transfer occurs when students apply previously learned material to new situations. A distinction between "near" and "far" transfer is commonly drawn in the literature. Some transfer situations are argued to require a different use of the skills or information from the original learning context, underscoring the ability to transfer learned material beyond the particular situation in which learning occurred to essentially a novel or dissimilar situation known as <u>far transfer</u>. Accomplishing this illustrates the importance of what Baldwin and Ford (1988) define as the conditions of learning, that is, the maintenance of learned material over time and, more significantly, the ability to generalize those skills to novel contexts. In other situations, transfer can be understood as the application of learned material to a similar or closely related context known as <u>near transfer</u>.

As researchers Barnett and Ceci (2002, p. 612) argued in a Psychological Bulletin article, however, one of the problems in understanding whether transfer has occurred is that transfer researchers often fail "to specify the various dimensions along which transfer can occur, resulting in comparisons of 'apples and oranges'." The distinction between far and near transfer does not specify whether contextual similarity is high or the nature of the time lag.

To remedy this, they articulate a framework that provides additional dimensions needed to better understand transfer. This framework, they argue, will help resolve current disputes regarding the pervasiveness of transfer. Their research focuses on far transfer (transfer to a dissimilar context) rather than near transfer (transfer to a more similar context) because far transfer is typically what trainers and educators seek to promote. They also argue that existing researchers have often failed to distinguish the difference between transfer as the result of true recall (spontaneous transfer) from transfer resulting from prompts or hints. In their view, it is important to distinguish the specificity and generality of the content, specifically to separate "the transfer of specific facts and procedures and of general principles" (Barnett and Ceci, 2002, p. 621). To address these issues, Barnett and Ceci created a taxonomy with two primary factors, including content (i.e., that which is transferred) and context (i.e., when transfer occurs). The content taxonomy is shown in Figure 2.

	Specificity	<	➤ Generality
Learned skill	Procedure	Representation	Principle or heuristic
	N	ature of Performance Change	
Performance change	Speed	Accuracy	Approach
	Low	←────	> High
Memory demands	Execute only	Recognize and execute	Recall, recognize, and execute

#### Figure 2. Taxonomy of far transfer - Content (Barnett & Ceci, 2002, p. 621)

The content dimension is designed to address both spontaneity and specificity/generality. The content dimension relates to the learned skill or knowledge that emerges from the transfer source, performance change, and memory demands (Barnett & Ceci, 2002). The specificity or generality of



the learned skill varies from specific fact or routine procedure, to a representation (e.g., tree diagram), to a general principle or heuristic for solving problems. Another aspect of content is the nature of performance change, which represents the gauge with which success is measured (e.g., speed, accuracy and/or quality). The third aspect of content is argued to be memory demands, and whether the transfer task requires recall, recognition or execution. Within experiments, then, this relates to whether people are expected to spontaneously demonstrate transfer or whether they are prompted.

	Near ←				$\rightarrow$ Far
Knowledge domain	Mouse vs. rat	Biology vs. botany	Biology vs. economics	Science vs. history	Science vs. art
Physical context	Same room at school	Different room at school	School vs. research lab	School vs. home	School vs. the beach
Temporal context	Same session	Next day	Weeks later	Months later	Years late
Functional context	Both clearly academic	Both academic but one nonevaluative	Academic vs. filling in tax forms	Academic vs. informal questionnaire	Academic vs. at play
Social context	Both individual	Individual vs. pair	Individual vs. small group	Individual vs. large group	Individual vs. society
Modality	Both written, same format	Both written, multiple choice vs. essay	Book learning vs. oral exam	Lecture vs. wine tasting	Lecture vs. wood carving

#### Figure 3. Taxonomy of far transfer - Context (Barnett & Ceci, 2002, p. 621)

The context dimension is intended to address the contribution of different contextual features to transfer on a continuum ranging from near and far transfer. Context has 6 relevant dimensions, including the knowledge domain, physical context, temporal context, functional context, social context, and modality (Barnett & Ceci, 2002). The knowledge domain represents knowledge which is specific to a particular application. Barnett and Ceci explain that the knowledge domain refers to whether the skill will be applied (e.g., Physics class to Chemistry class is nearer than Physics class to English class). The physical context refers to the near/far relationship between the physical learning environment and the transfer environment (e.g., classroom to field exercise). Obviously, the content of what is being taught will largely determine what is required to maximize training benefits. Next, temporal context considers the amount of time that has elapsed since the training and evaluation phase. The functional context refers to the purpose of the skill or knowledge, how that defines its usage (e.g., academia or real world), and how that ultimately impacts the bearer's perception and attitude toward it. Social context considers if the skill or knowledge was attained while alone or in a group setting, as this may impact on retention. Finally, modality refers to the format of the learning and transfer task (e.g., hands-on or multiple choice questions).

Of the context dimensions, Barnett and Ceci (2002) argue that the knowledge domain and physical and temporal contexts are the most critical for educational purposes because educators would want to impart knowledge that can be utilized outside the classroom and be maintained over time. They also suggest that the functional context is an important dimension specifically for military training



because there is a desire to see military training transfer to a very different functional context (e.g., simulated to real combat situations). The intention of military training, they state, is "not just to teach trainees how to succeed on training course examples, but to build skills that then transfer to myriad variations that may be encountered on the job" (p. 613 - 614).

Barnett and Ceci argue that this taxonomy can be used to systematically evaluate research findings and claims. Investigating the dimensions associated with the content and context of transfer (and their interactions), they argue, will help to make more valid generalizations about successful transfer. Specifically, when considering the transfer from training scenarios to real-world situations, the impact that context has on transfer should help assess the effectiveness of education and training investments. As Barnett and Ceci point out, many studies that they included in their brief review of the literature failed to consider these dimensions, and oversights by previous researchers may detract from the ecological validity of existing studies.

At least 2 different sets of researchers have noted the importance of representing the different types of skills relevant within a transfer of training domain, distinguishing between open and closed skills (Yelon and Ford, 1999) and "near" vs. "far" forms of skill transfer (Barnett and Ceci, 2002). The content of training and the nature of the skills being trained can affect the transfer of training. A 2-dimensional distinction has been made in research by Yelon and Ford (1999). The first dimension is called task adaptability, which refers to whether skills are closed or open. Closed skills are defined as those that require one specific prescribed response, based on adherence to an established set of rules. For example, a car mechanic making a simple repair (e.g., changing the turning lights) must follow a relatively established set of precise procedures (Baldwin, Ford and Blume, 2009). Open skills, on the other hand, do not have one single correct way to be completed. The performance of these skills can be considerably more variable, and involves more general principles rather than a set of procedures. For example, a manager attempting to teach staff how to motivate their employees would not have access to an easy set of pre-defined steps (Baldwin, Ford and Blume, 2009), but would need to use more general principles. The second dimension involves the extent of supervision. As downsizing has occurred in many organizations, levels of supervision have often shifted from considerable and direct supervision to more autonomous supervision.

Yelon and Ford (1999) have argued that these 2 distinctions are important because the workplace has gradually been evolving and requires fewer closed skills (e.g., physical demands) and more open skills (e.g., cognitive demands), and lower levels of supervision. This shift is important because training has typically been designed to focus on closed rather than open skills. A matrix showing the interaction of the task adaptability and degree of job supervision dimensions is shown in Figure 4.





#### Degree of Job Supervision

#### Figure 4. Dimensions likely to influence transfer (Yelon and Ford, 1999, p. 62).

They argue that Quadrant 4 (where skills are open but the work is relatively autonomous) is likely to present the most challenge to transfer researchers. This type of work provides no clear standards by which to assess job performance and to evaluate job impact after training. This conceptual research makes an important contribution and an important distinction that is not prominent in the existing transfer literature or research.

#### 3.4 Discussion

The literature reviewed to this point has important implications for understanding team transfer. The first obvious problem that is not entirely resolved even outside of the specific team domain is exactly how transfer should be defined.

The theoretical distinctions offered by Yelon and Ford (1999) and Barnett and Ceci (2002) foreshadow one of the most important limitations of the existing literature. Specifically, this is the failure of researchers to clearly define the types of skills they are attempting to train (and then transfer), and the type of transfer (near or far) they are seeking. The context within which efforts to promote transfer occur (e.g., functional or social) is also a critical factor in the success of transfer efforts. This current lack of specificity in the literature has made it very difficult to understand the factors that reliably influence transfer because the corpus of empirical research has not built systematically on a common structure. At the very least, then, it will be critical when considering team transfer and adaptation to be conscious to clearly attend to these important distinctions. The next section describes empirical research investigating transfer from a cognitive perspective.



# 4. Cognitive Transfer Research

### 4.1 Analogical Reasoning Research

Although the literature has not developed in a clearly linear fashion, this chapter is organized by the year of the research reviewed in order to show the gradual progression of research and growing understanding about how analogical reasoning influences transfer. As will become apparent throughout the chapter, researchers exploring the nature of transfer put varying emphasis on the different phases of the analogical reasoning process.

#### 4.1 Schema Development

In Mary Gick and Keith Holyoak's (1983) seminal work on transfer, the focus on analogical reasoning was primarily in the mapping phase. Indeed, for these researchers, transfer required mapping two concepts at the same level of abstraction in order to identify corresponding features. In their own words, this process requires "finding an initial partial mapping between two analogs and then extending the mapping by retrieving or creating additional knowledge about the analog [i.e., the target source] that was initially less well understood" (Gick & Holyoak, 1983, p. 5). Enabling the analogy for transfer, they continue, requires the combination of the mapped identities into a shared schema (e.g. "problem schema") to produce schema convergence. Gick and Holyoak argue that an individual can perceive correspondences between the known problem and the "yet to be resolved" problem, and from this induce an analogous solution to the latter. The schema can be understood as the "abstract category" of which the analogs are instantiations. The greater the abstraction, the further removed the category is from a particular situation. According to Gick and Holyoak, mapping of two analogs can occur only to the extent that the schema does not provide an alternative view, the analogs' similarities and differences are recognizable, and the level of abstraction is compatible with the two analogs.

In earlier research, Gick and Holyoak (1980) found that many participants were unable to spontaneously notice analogies without the assistance of the experimenter ("teacher") to make them salient. In later studies, Gick and Holyoak (1983) were interested in determining how analogies become noticed and then used to solve new problems. Essentially, they were interested in how story analogs get encoded prior to the transfer target task. They believed that identifying similarities between two analogs by way of a shared schema may promote analogical transfer. Analogical reasoning is possible, they argue, because people can connect structurally similar problems within a shared schema, producing what they call convergence. A shared schema (e.g., "problem schema") should, therefore, invoke the causal aspects of the situation, making the analogy more probable than simply mapping using individual analogs (Gick & Holyoak, 1983). For Gick and Holyoak, a schema is understood as the correspondence between at least two analogs.

To investigate the impact of inducing a schema to produce analogical transfer, they conducted a number of experiments. The first 3 studies were efforts to produce analogical transfer using only a single analog. For example, in Study 1, participants were given an initial story analog, and told that they would be asked to either recall the story or simply summarize the story later (3 minutes after reading/studying it). Participants were divided into three groups: <u>analog recall</u>, <u>analog summarize</u>, and <u>control summary</u>. Once they had either recalled or summarized the story, they were asked to complete the transfer target task (a problem-solving task) first with no hint and then with a hint. Citing previous research, Gick and Holyoak hypothesized that summarizing may actually invoke



more schema abstraction than mere recall. It was assumed that summarizing would activate the underlying structural elements of the story, and that simple recall which would be constrained to the superficial elements. However, results showed that there was no difference between the two experimental conditions when it came to schema abstraction and analogical transfer. Both groups resolved the target problem in a similar way.

Gick and Holyoak (1993) – Study 1 only			
Methodology Used	Problem solving		
Source/Cue/Training	A "birthday party" problem was the analogy		
Probe/Test/Outcome	Solution of the "cord problem"		
Independent Variables	Analog recall, analog summary and control summary Hints before and after		
Dependent Measures	Participant's description of the solution (i.e., how many solutions provided) Rating of the story relevance and prior familiarity with solution		
Findings	Recalling and summarizing the story had the same impact on solution rates after a single analogy or case		

#### Table 3. Gick and Holyoak – Study 1 (1983)

The second experiment by Gick and Holyoak (1983) used a more direct approach to invoking the problem schema. This study added a verbal statement that indicated the principle underlying the problem schema to see whether this would promote better transfer. Again, even with the principle articulated, there was no significant gain in transfer. The third study added a diagrammatic depiction of the principle and also showed no significant results. These initial three studies conducted by Gick and Holyoak (1983) failed to demonstrate spontaneous transfer and also did not appear to facilitate schema abstraction. They reasoned that this was a result of providing only one analog.

In the fourth experiment, Gick and Holyoak (1983) included two experimental groups that received two similar analogs and two dissimilar analogs, as well as a control group that received an analog story and a disanalog story. Participants read the story and provided summaries of them. To encourage comparison between the two stories, they were allowed to keep the stories together while they answered questions about them. Then, in the hope of eliciting mapping and inducing a convergence schema, Gick and Holyoak asked participants to draw similarities in writing between the two stories. These descriptions were later scored according to the presence and quality of schema. Participants also rated the similarity of the story analogs they read. Presented with the transfer target task, participants were asked to resolve the problem without a hint first and then with a hint (namely, to use the previous story analogs to help resolve the current problem) when confronted with the target analog.

Results of Gick and Holyoak's (1983) fourth experiment showed that total solution frequency did not differ in the 2 similar and dissimilar story analog conditions. Hence, these two comparison groups were combined. Comparing the control group which only received one analog with the combined experimental groups shows that participants who received two analogs had a significantly higher total solution frequency. It seemed that having two analogs rather than one improved transfer to the target problem-solving task. Fewer participants in the control group of experiment four solved the problem compared to those in previous experiments who received one analog story. Gick and Holyoak suggest the disanalog story may have actually interfered with the



resolution of the transfer target task. Results also indicated that participants who generated higher quality descriptions of the similarity of the two stories also had greater transfer performance. In fact, a high number of participants who generated higher quality descriptions also resolved the transfer target problem spontaneously (i.e., without a hint).

Gick and Holyoak (1983) – Study 4			
Methodology Used	Problem solving		
Source/Cue/Training	A "birthday party" problem was the analogy		
Probe/Test/Outcome	Solution of the "cord problem"		
Independent Variables	Two similar analogs, two dissimilar analogs, analog-plus-control, disanalogous control story Hints before and after problem presentation		
Dependent Measures	Participant's description of the solution (i.e., how many solutions provided) Rating of the story relevance and prior familiarity with solution Quality of the schema rated by judges		
Findings	Two analog condition combined for analyses – before a hint, 45% of participants in 2 analog conditions generated solution, and only 21% of participants generated a solution in relation to only one analog 91% of participants who generated good schemas solved the problem without a hint Comparison promotes better problem solving, perhaps via better schema induction		

However, Gick and Holyoak caution that strong writers might simply be strong problem solvers who effectively use analogical reasoning. In their fifth experiment, they attempted to dismiss this alternative account.

In their fifth experiment, Gick and Holyoak (1983) included a verbal statement that attempted to focus participants' attention to the critical elements of the problem schema underlying both analog stories. Participants again read two story analogs, and half received the principle at the end and the other half did not. Participants were asked to summarize the stories, describe ways in which they were similar, and rate their similarity. Then, participants resolved the transfer target problem again without a hint and then with a hint. Results showed that participants who received the principle showed significantly better spontaneous transfer performance. Moreover, results showed that participants who had received the principle also wrote higher quality descriptions of the similarity between the two analogs, and this impacted transfer performance. Gick and Holyoak argue that the verbal hint calling attention to the critical elements of the schema underlying the analog stories makes the schema more salient, and this improves performance in the transfer task. Overall, regardless of the experimental condition, most participants who wrote "good to intermediate schema descriptions" eventually resolved the transfer target problem. According to Gick and Holyoak, this finding demonstrates the impact of formation and use of schema in analogical transfer.



In a final experiment, Gick and Holyoak (1983) found that the introduction of a visual aid produced a high frequency of analogical transfer for participants in both the similar and dissimilar analog conditions. Moreover, the quality of the schema descriptions also positively impacted transfer performance. In fact, when the diagram was presented to those participants with dissimilar analogs, they had higher quality schemas than those with the similar analogs. Gick and Holyoak (1983, p. 30) interpreted this finding to indicate that "mapping between relatively disparate analogs, when guided by a device that highlights the underlying solution principle, may be more likely to generate the optimal schema". However, even these higher quality scheme descriptions did not produce significantly higher frequencies of transfer when compared to results in the similar analog condition.

In subsequent studies, they provided participants with two story analogs in an effort to induce the appropriate schema to produce transfer to a third story analog. Citing the pros and cons associated with the impact of diverse examples on transfer, they suggest that learning a concept from dissimilar examples is a challenge, but once it has been learned, the concept can be used more flexibly than a schema induced from similar analogs. This may be in part because comparing two dissimilar analogs is more likely to activate abstract underlying principles of the schema rather than simply the surface features. Gick and Holyoak argue that this might permit transfer to a disparate problem task more readily. However, they also point out that mapping may be difficult because unlike similar analogs, two dissimilar analogs have many differences and few similarities.

The results of this classic experiment show that promoting instantiations of a general schema fosters transfer more readily than simply providing general principles. Indeed, Gick and Holyoak (1983, p. 30) showed that "a manipulation that facilitated schema induction increased the degree of analogical transfer". The mapping phase of analogical transfer seems to be more solidified when more than one analog is available prior to target transfer.

Following their experiments, Gick and Holyoak (1983) concluded that:

- comparing two analogs rather than one promotes mapping to a general convergence schema more readily;
- aids that facilitate the relevant and underlying elements produce abstraction of more optimal (i.e., more general) schema, and;
- schema induction may promote analogical transfer.

Explaining the low rates of transfer from one single analog to another, Gick and Holyoak (1983) suggested that this may be the result of having no guidance or instruction from a teacher. Moreover, when considering the few individuals who spontaneously transferred from one analog to another problem analog, Gick and Holyoak (1983) suggested that these individuals may have brought "prior knowledge" to bear on the transfer problem task. They argue that such prior knowledge from one domain, encoded at an abstract level, may actual transfer to another domain. As will be seen later, both prior knowledge and the utilization of resources in one's learning environment (such as teachers, colleagues, texts, etc.) are important characteristics of promoting transfer, and might ultimately explain why failure to consider these environmental elements in accounts of transfer may contribute to the low rates of transfer (Bransford & Schwartz, 1999).

Subsequent research by Gentner, Ratterman, and Forbus (1993) focused on how people map structures in order to perform analogical reasoning. This work examined the role of similarity in comparing source and target problems and its impact on memory retrieval during transfer. For example, they asked "what kinds of similarity do people think constitute a good match?", "what



kinds of similarity promote access to long-term memory?", and how the answers to these questions relate to one another. Based on the evidence from earlier transfer studies (e.g., Gick & Holvoak, 1983), Gentner et al. believed that retrieval from long-term memory would rely on surface features rather than on relational structures. This work also investigated how people made judgements about the soundness of analogies (e.g., the analogy "a camera is like a tape recorder" is more sound than "the sun is like an orange"), and whether perceptions of soundness would be driven by structural similarity or surface similarity among analogs. Catrambone (2002) provides a thorough description of ways a pair of base and cue stories can match. Surface-level matches occur when similar entities (i.e., the specific objects) in the source and target stories appear "match" on surface characteristics (e.g., hawk and eagle). In contrast, structural matches occur on two levels. First-order relations (FORs) specify the *relationship* between two entities in a story, for example "shoot" (hunter, hawk), while a first-order match arises when *similar* FORs are present in a target story, for example "fire-on" (country1, country2). In a similar manner structural matches can occur at the level of higher order relations (HORs), which use entities and FORs as arguments. The authors provide an example: "CAUSE [LACK (arrow, feathers), MISS (arrow, hawk)], which roughly translates into "the lack of feathers on the arrow caused it to miss the hawk" (Catrambone, 2002, p. 319). If a target story shares an HOR resembling an HOR in the source story, there is said to be a higher-order match. Overall, the authors argued that HORs or analogical matches should be rated as more sound than either surface-level matches or first-order matches.

In Study 1, Gentner et al. (1993) placed participants in one of three groups to counterbalance the story pairs they received. These story pairs were designed to have varying levels of similarity between the source story and the cue story. The first was first-order match (low level predicates, such as "shoot" and "fire"), and the cue stories shared only first-order relations. The second was surface-similarity, and these cue stories shared both first-order matches and object matches (e.g., characters, physical objects and location). An example of a surface feature match would be hunter and hawk vs. sportsman and eagle. The third was analogy cues, and these combined first-order and higher-order relations. An example of a higher order relation is "An attack is made but fails; this causes the one being attacked to offer to provide an item to the attacker to help the attacker; this offer causes the attacker to be grateful and to promise not to attack again" (Catrambone, 2002, p. 319).

Participants were asked to read 32 stories (18 test and 14 filler) carefully so that they could remember them in a week's time. One story acted as the source and three were the cue matches, differing in amount and level of similarity with the source (see Gentner et al. for sample stimuli for the experiment). According to Gentner et al., cue matches all shared identical or nearly identical first-order relations with the source analog. Participants only received 1 matching target story for each of the 18 source stories and received the same memory sets, which only varied in the type of story. To serve as a pure memory test, they added an unrelated sentence at the end of each story that contained a predefined word.

Approximately a week later<sup>1</sup>, the participants were then asked to read the 18 cue stories and document any correspondences (names of characters, motives, events) to the source stories. They were asked to write down anything that reminded them of the first set of stories in as much detail as possible. The measures of participants' recall of the source analogs included experimenter ratings, proportion of recalls rated above criterion, and proportion of recalls of a predefined word. Receiving pairs of stories from the recall task, participants were then asked to rate the soundness of

<sup>&</sup>lt;sup>1</sup> This delay, they reasoned, reduces effects of experimental demand and acts as a more realistic evaluation of memory retrieval.



the matches, where soundness would allow one to "infer or predict much of the second story from the first" (p. 534). Soundness was defined as related to structural consistency and systematicity rather than surface similarity (or object attributes).

Results showed that for accessing information in the retrieval task, the surface similarity matches provided the most effective reminding cues. For all 3 measures of recall, analogy matches were significantly less effective than the surface-similarity matches (but more effective than first-order relations only). However, participants rated using a higher-order relational structure as a basis for analogy matches as providing a better basis on which to make judgements than using first-order relational and surface similarity matches.

Gentner et al. (1993) concluded that the impact of similarity on transfer needed to be reconsidered, given the discrepancy between what actually people retrieve from memory (surface features) and what people want as an indication of sound analogical reasoning (structural features). This theme of an inherent disconnect between what we want to use as a sound indicator and what we are actually able to retrieve from memory (i.e., surface features) is a very interesting one, and one which re-emerges at several points in the available literature.

Gentner et al. (1993) – Experiment 1 only					
Methodology Used	Recall of stories matching in various ways				
Source/Cue/Training	They read 18 original stories at Time 1				
	At Time 2 (1 week later), they read 18 cue stories consisting of six structural similarity (SS) cues, six analogy match (AN) cues, and six first-order relationship (FOR) cues.				
Probe/Test/Outcome	Recall of the features of the original story				
Independent Variables	18 stories divided into 3 sets of 6 – 3 x 3 group (between)				
	Similarity type (within participant)				
Dependent Measures	Remindings (recall of the original stories, proportion of recalls above criterion, proportion of recalls of a defined criterion)				
	Soundness (judge and participant ratings)				
Findings	Structural similarity matches served as the best reminding cues				
	Soundness was rated as higher for the analogical matches – SS and FOR not different				
	Even though people use surface similarity to make comparisons, they recognize that structural similarity provides a better analogical basis (as indicated by soundness ratings)				

#### Table 5. Gentner et al. - Study 1 (1993)

A line of more recent analogical reasoning research relies on the emergence of contingent contracts during negotiations. These are distinct from trade-off contracts. Trade-off contracts are arrangements "in which each party accedes to the other's desires on an issue that is relatively unimportant to be in exchange for making gains on a highly valued issue" (Gentner, Loewenstein and Thompson, 2003, p. 395). Contingency contracts are a complex contract that allows each party to maximize their own interests based on their future expectations about how the contract will meet their own interests. A contingent contract represents more than acceding to another party's demands.



Blanchette and Dunbar (2000) argue that previous work on analogy has underestimated the ability of people to use structural similarity when making analogies. Leveraging the generation effect in recall (i.e., recall is superior for generated vs. read stimuli), their research explored whether the effect would generalize to the recall of analogs (i.e., structure features) when people generated their own source analog (instead of having one provided for them). According to Blanchette and Dunbar (2000), laboratory studies may constrain participants' search for structural similarities because they simply receive the source and target analogs ("reception paradigm") as opposed to what generally occurs in the "real-world" where the source analog is generated from a target analog ("production paradigm"). Though Blanchette and Dunbar were not studying "transfer" per se, they were interested in exploring the retrieval of superficial features versus structural features in analogical reasoning. Blanchette and Dunbar hypothesized that participants operating in the production paradigm would generate more analogies based on the structural features rather than superficial features, and conducted three studies to test this hypothesis.

The findings from Blanchette and Dunbar's (2000) three studies support their overall hypothesis that given an opportunity to generate analogies (production paradigm), people create analogies that are structurally similar, whereas when they are asked to find a relationship between two given analogies (reception paradigm), people base their analogies on superficial similarity. Specifically, the results showed that the analogies that participants produced shared structural similarities with the target problem, especially when participants acted independently (as in Study Two).

Blanchette and Dunbar (20	000) – Study 2 only			
Methodology Used	Production paradigm involving the creation of persuasive political arguments			
Source/Cue/Training	Participants given a problem and were asked to generate persuasive analogies that supported their viewpoints			
Target/Test/Outcome	Persuasive analogies produced in response to the zero deficit problem			
Independent Variables	Pro zero-deficit and anti zero-deficit			
Dependent Measures	Production measures (e.g., number of analogies) Analogies (coded by semantic category of source, semantic similarity with targe analogy, relational structure relative to target, explicitness of mapping) Participant ratings of the best 2 analogies they had created			
Findings	Sources generated had low levels of similarity with target problem Analogies based on complex underlying structures When people actually generate the source in response to the target (rather than simply retrieving it), they rely on structural (not surface) similarity			

Table 6	. Blanchette	and Dunbar	- Study	2	(2000)
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Considering why participants focused on structural similarities when generating analogies and why participants focused on superficial similarities when asked to remember which source is most like the target analog, they argue that the difference may lie in the encoding process. For example, typical transfer paradigms require participants to learn the source analog while expecting that they may have to recall or retell the information at a later time. Blanchette and Dunbar argue that their experimental procedure (i.e., asking participants to rate the pleasantness of the source) was a similar method, and this "standard paradigm implicitly cues the subjects to encode the superficial features and hence these features are used in retrieving analogical sources" (p. 14) rather than the structural features. These results may promote the faulty conclusion that transfer occurs only when



the source and the target share identical elements (Thorndike & Woodworth, 1901), reflecting less complex forms of transfer. However, Blanchette and Dunbar demonstrated that when asked to produce analogies, participants are actually quite good at it. To do it, they use structural similarities (optimal schema abstraction) as opposed to superficial similarities more frequently. With an increase in processing of information, it seems that structural features can play a greater role in accessing source material and analogical reasoning (Catrambone & Holyoak, 1989, cited in Catrambone, 2002).

Catrambone (2002) argues that the lack of link between structural commonality and retrieval (as shown in Gentner et al., 1993) is puzzling. He suggests that the research uses discrepant methodologies (and hence produces inconsistent results), making it impossible to pinpoint the factors that influence the effects of structure on "remindings" or retrieval. He argues that precise manipulations in experimental designs may be necessary to reveal the true impacts of structural and surface similarity.

Catrambone developed and tested source and cue analogs while systematically varying the <u>number</u> of surface and structural matches between them to explore the impact on retrieval. He also argued that how source material was encoded (i.e., using either deep or shallow processing) was also critical. He explains, "with minimal processing…a coherent story structure is unlikely to be constructed by the learner, thereby making structural features less prominent in representation" (p. 320). Rather than using recall instructions requiring only minimal processing (e.g., such as instructions given to Gentner et al. 1993 to read the story in order to remember it a week later), Catrambone incorporated elaborate processing instructions in his experiments in order to advance participants' deeper processing of the source analog.

A short pilot study was first conducted to test the number of matches in the stories to be used for subsequent research. Cue story entities (objects) and FORs (actions and events) were systematically manipulated in creating these stories, and there was good agreement in participant and experimenter's ratings of matches between entities, and between FORs, within story pairs.

The first experiment had four conditions, representing four different combinations of entity matches (similarity) and first-order (structure) matches. Participants were randomly assigned to conditions and read the 15 base stories and were asked to remember them as they would be coming back a week later to read more stories. To ensure deep processing of the source stories, Catrambone asked participants to rate the source analog stories for imageability and plausibility, via measures used successfully in previous research to increase the level of processing (Wharton, Holyoak, Downing, Lange, Wickens, & Melz, 1994, cited in Catrambone, 2002). The second phase of the experiment, occurring a week later, had participants conduct an unrelated task before reading the 15 cue stories and documenting similarities to the source stories. The proportion of "remindings" between source and target stories was measured. Results showed that increases in the number of entity matches, as well as first-order structural features increased retrieval of source stories.

In his second experiment, Catrambone (2002) manipulated the higher-order relations. Gentner et al. (1993) had found that access was higher for source-target matches sharing both first-order relations and higher-order relations than for matches that had only first-order relations. The opposite was true for surface features. Accessing matches did not require the addition of higher-order relations. Catrambone manipulated surface features, first-order relations, and presence or absence of higher-order relations. Source stories were held constant, whereas the target stories had 18 versions. Participants received the source story and one of the 18 target stories. Procedures were similar to those in the first experiment. In this experiment, Catrambone found that an increase in the number


of matches in surface features <u>with or without matches in structural features</u> led to a greater reminder of the source story. Results also showed that when first-order structural relations were accompanied by one or more higher-order structural relations, this did aid access to base and cue story matches.

Catrambone (2002) – Experiment 2 only		
Methodology Used	Recall of stories matching in various ways	
Source/Cue/Training	3 base stories and 3 cue stories were matched (12 base- fillers and 12 cue-fillers)	
Probe/Test/Outcome	Recall of the base stories (1 week later)	
Independent Variables	$3 \times 3 \times 2$ between subject design – number of entity matches (2, 4 or 6), number of first-order relation (FOR) matches (2, 4 or 6) and whether or not higher order relation (HOR) match	
Dependent Measures	Proportion of remindings of the base story once exposed to the cue story	
Findings	Main effect of remindings related to entity matches or surface similarity (not true for FOR or HOR)	
	Only significant interaction between FOR and HOR – remindings were higher when high HOR matches and high FOR matches	

Table 7. Catrambone – Study 2 (2002)

The third experiment examined the impact of reading time had on access to source material at the time of test. Research suggests that as readers fill in gaps and develop coherence through inference and elaboration, reading time increases (O'Brien & Myers, 1985, McNamara & Kintsch, 1996, both cited in Catrambone, 2002). Thus, he argued that if someone is reminded of an earlier story when reading a target story, inference or elaboration about the target would require more time than if one was not reminded of the source story.

Results showed that participants with explicit instruction took longer to read the cue (target) stories than those who did not read the base (source) story, suggesting that thinking about a prior story while reading another increases reading time. As well, reading times significantly increased in the spontaneous-reminding condition when there was more surface feature overlap between the cue and base stories. Similarly, reading times significantly increased with more first-order structural relation overlap, suggesting that first-order structural matches can lead to more remindings and, unlike the second experiment, access did not require the presence of a higher-order structural relation.

In general, Catrambone's (2002) findings suggest that the <u>number</u> and not the type of overlapping surface or lower-order structural features are the main contributors to retrieval. As well, the impact of structure on retrieval is increased with more higher-order relations, as shown in the second experiment. This effect, he argues, can be explained by the concept of alignability (i.e., "the idea that a series of lower-level structural matches between a base and a cue need to have matching arguments (relations) and one-to-one correspondence of the elements that are in the arguments" from Gentner & Markman, 1997, cited in Catrambone, 2000). He argues that alignability increases with the sharing of similar higher-order relations, especially when the connection is salient (Clement, Mawby and Giles, 1994, cited in Catrambone, 2000). Hence, this research suggests that "[e]ven when first-order relations match between stories, if there is not a higher-order relation to help put those first-order relations into some sort of alignment, then access does not get a reliable boost" (Catrambone, 2002, p. 330). On the other hand, when it comes to access, alignment is not necessary for accessing



surface features. Like the findings in Blanchette and Dunbar (2000), Catrambone's study suggests that deep level processing facilitates transfer from source to target analogs.

Another study by Gentner, Loewenstein and Thompson (2003) considered analogical encoding (comparing two examples and identifying the underlying structure), and its relation to subsequent transfer. One of the notable problems in the literature, they argue, is the problem of inert knowledge. Even when people have gained the knowledge required to solve a new problem, they are often unable to access the required knowledge and expertise. This is particularly true when there are surface differences from case to case. They explain that the advantage of their form of analogical encoding (which contrasts with typical forms of analogical learning) is that trainees are highlighting and clarifying a new concept as a result of the comparison. This differs from typical notions of analogy and transfer, where trainees are expected to acquire knowledge about a target problem by invoking an analogy that is already firmly understood. According to Gentner et al., mapping in analogical encoding is bidirectional, meaning that "whatever is understood about one example can serve to shed light on the other" (p. 394). As mapping moves between cases, they suggest that people develop general problem-solving schemas that capture the common structural elements rather than situation-dependent surface features. These schemas will be retrieved more readily, they argue, because comparing the examples across domains will not be hampered by idiosyncratic elements. Moreover, one does not need expert domain knowledge to make this comparison useful in transfer. Further support for their point comes from previous research showing that learning abstract concepts by comparing examples allows for effective use of these concepts long after initial learning (Fong & Nisbett, 1991, cited by Gentner et al., 2003).

Using negotiation training as their platform, Gentner and colleagues (2003) conducted a number of studies to investigate analogical encoding and transfer. In their first study, participants received two cases of either trade-off or contingent contracts. Participants (university undergraduates, n = 48) in the experimental condition were trained by being asked to compare two examples of a particular contract in which the resolution was either a trade-off or contingent contract. In the two experimental conditions, analogical training aimed to help participants through the analogical encoding process and to help them to articulate the common principles within the contracts. In the trade-off guided-analogy condition, participants received training materials containing the definition of the key principle (i.e., trade-off), an example of that principle (with a diagram), a second example of the same principle and instructions for completing a diagram depicting the structure of the second example. Participants in the contingent-contract guided-analogy condition received similar materials using contingent contract examples. In the baseline condition, participants completed the test negotiation problem with no analogy training. Once they had compared the two cases, experimental participants were asked to solve another negotiation problem that differed only in surface features. The test negotiation was constructed so that one of three negotiation strategies could be utilized: a suboptimal compromise strategy (i.e., negotiation parties meet half-way), a trade-off strategy, or a contingent contract. Once participants completed the test negotiation, they were asked a few questions to ensure they had understood the material (e.g., topics, rankings of negotiators' priorities, whether negotiation hinged on future outcomes). Participants wrote down the solution strategy that they would exercise to resolve the problem and why they chose that particular strategy. They were then asked if they were reminded of any of the study cases when they were considering the test case. Following this, they were asked to propose a second solution, having just been reminded of the study cases. Solutions were coded by experimenters blind to the participants' condition.

Results in this first study showed that 47% of the participants who were asked to compare two similar cases proposed solutions that matched the negotiation principles to which they were



exposed in the training phase (i.e., either contingency or trade-off) and only 6% of baseline participants proposed contingency contracts or trade-off solutions. Solution strategies proposed by participants also favoured the principles that participants had learned prior to test. Moreover, when resolving the test negotiation, 65% of participants reported that they were reminded of the training cases when developing their strategy. There was also specific evidence of the importance of the principles learned in training, with 44% of contingency principles trainees forming a contingent contract, and 50% of trade-off trainees proposing a trade-off solution. This suggests that specific learning of principles while invoking a comparison process may have influenced transfer. However, they also explained that the advantage of the training cases could have been a result of learning the principles by reading each of the cases rather than of actually comparing the two cases.

In the second experiment, Gentner and colleagues (2003) examined impact of the comparison and schema usage more directly. They argue that comparison helps develop problem-solving schemas and hence leads to higher rates of learning and transfer. To investigate this, they asked participants to either compare the two cases (comparison condition) or to study them one at a time (separate case condition). They also examined participants' open-ended statements about the principles they learned in the training session. Results from the second experiment confirmed Gentner et al.'s (2003) hypothesis that comparing cases rather than analyzing them separately would led to greater understanding of the schema and greater transfer. Specifically, twice as many participants transferred the principle in the comparison condition over the separate case condition. Moreover, similar to those in the baseline condition in the first experiment, those in the separate case condition showed high rates of using the compromising strategy to resolve the test negotiation problem. However, regardless of condition, many participants said that they were not reminded of the study cases when resolving the test negotiation. Those in the comparison condition also stated the principles underlying negotiation more often and completely, but this was only significant for those who had received the contingent strategy. Participants in the separate case study, however, did not report linking the two study cases, leading Gentner et al to conclude that "learners tend not to spontaneously compare cases that lack surface similarity-even when the two cases are presented in immediate succession" (p. 400). In fact, they state that "the critical step appears to be drawing a comparison between examples to extract their common structures" (p. 400).

In their final experiment, Gentner and colleagues (2003) explored whether the learning benefits of undertaking analogical encoding could extend to actual negotiation behaviour. They used a singleissue face-to-face negotiation task between an employer and employee as the transfer task. This kind of task is commonly used in conflict management research (Bazerman, Curhan, Moore, & Valley, 2000, cited in Gentner et al.). This study also compared the impact of using formal guided analogy training (as used in Study 1) with simple instructions to compare cases (as used in Study 2). As such, four conditions in this experiment included a guided analogy training condition, comparison condition, separate-cases condition and a baseline condition (no training session). Gentner et al predicted greater schema quality and transfer for participants in the first two conditions. They also predicted the participants in the guided analogy training condition would form more contingent contracts (the selected choice of contract for this experiment given the negotiation context) followed by the comparison condition, the separate-cases condition and the baseline condition.

Results supported researchers' predictions, as guided training was beneficial to the face-to-face negotiation. Participants in the guided analogy training condition formed more contingency contracts than those in the comparison condition, followed by those in the separate-cases condition and those in the baseline condition. Participants in the comparison condition showed greater schema description quality than in the separate cases condition. A combined score from negotiation



partners indicated a general trend that those with high schema quality also transferred the principles more readily to the negotiation context. As well, participants in the comparison condition linked the two cases more frequently than those in the separate cases condition. Finally, those in the guided analogy training condition acknowledged the similarity between the training phase and the actual negotiation more readily that those in the comparison condition (followed by the separate cases condition). Asking novices to compare cases improved their negotiation performance, especially when participants were guided through the process and received supporting definitions and diagrams (guided analogy condition). As Gentner et al. concluded, "drawing comparisons helps participants acquire a coherent and portable relational structure" (p. 402). In general, analogical encoding (i.e., comparing cases) led to higher quality schema development (i.e., schema descriptions that contained more principles), greater transfer of principles to novel situations, and gains specific to the principle taught.

Gentner et al. (2003) – Study 3 only		
Methodology Used	Analogical encoding training	
Source/Cue/Training	Two cases related to negotiation	
Target/Test/Outcome	Face-to-face negotiation with a partner	
Independent Variables	Type of instruction – guided analogy training, comparison, separate cases or baseline (no instructions)	
Dependent Measures	Questionnaire - type of solution reached, similarity to training cases, linking of cases, suggestion of ideal settlement Experimenter coding of schema quality	
Findings	Participants trained using guided analogy made more contingent contracts, followed by those asked to compare, separate cases, and baseline Participants in comparison conditions showed more well formed schemas Trend for dyads that expressed better schemas to show better transfer, but this was weak	

#### Table 8. Gentner et al. – Study 3 (2003)

As Kurtz and Loewenstein (2007) note, a key question of great interest to analogical reasoning researchers is what keeps people from being able to retrieve analogies and information that they have already learned. One of the conclusions is that they simply did not learn it adequately the first time. Rather than focusing on the problem of initial learning, researchers such as Kurtz have focused on the role of problem representation. Viewing analogical reasoning from this perspective puts the emphasis not on the acquisition of learning but on how learned examples are actually stored in memory.

New research by Day and Goldstone (2011) specifically addresses the nature of the relationship between mental models and transfer. Noting that spontaneous analogical transfer has often been shown to be related to "concrete and contextual similarities" (p. 551), this work explores how similarity influences transfer via the creation of mental models. They argue that mental models can range from a somewhat literal representation of a situation (e.g., a pulley system) to represent abstract linkages between the initial situation and its analog (e.g., understanding electrical currents by using analogies such as water flow or to how crowds behave; Gentner and Gentner, 1983). Day and Goldstone argue that transfer is facilitated not by the overt similarities between two cases, but by the types of mental representations that individuals create when working to understand a



situation. Specifically, they argue that when cases are compared in generic principle-based terms (rather than in context-specific ways), transfer is likely to be better.

Principle-based comparison, they argue, explains why experts might perform better. When comparing multiple cases, they argue, experts are more likely to overlook the surface similarities while emphasizing the underlying principles that link these cases. These benefits are argued to stem from "the development of more abstract cognitive representations" or mental models that emphasize common structural features in order to promote transfer.<sup>2</sup> A related finding is that surface similarities between two entities can impede transfer (Day and Goldstone, 2011). This suggests that reducing the concrete content of cases may improve reminding and facilitate transfer. For example, Day and Goldstone (2011) note that attempting to understand the structure of an atom using the analogy of the solar system, emphasizing the notion of both systems as an "abstract structure of multiple entities that resolve around a more massive core" (Day and Goldstone, p. 551) would be more relevant to understanding the link than would emphasizing the colour and temperature of the sun.

They argue that the explicitness or implicitness of the representation is also another important influence on the transfer process. They also note that reminding people to reconsider an explicit representation of a past situation can help to improve transfer. On the other hand, they argue that the value of implicit representations (e.g., mental models) in promoting transfer has not been well-investigated.

When attempting to transfer knowledge of one task to another, they argue that even highly dissimilar tasks can have concrete similarities. They argue that the most effective mental models would include "analog, spatial representations of the system but also explicit representations of less directly perceptual information, such as temporal and causal relationships, and the dynamics of interacting forces" (p. 552). They emphasize that whereas much of the existing transfer research has relied on "the transfer of discrete insight solutions between text passages", their experimental task required "interaction with a dynamic system in service of achieving a specific goal".

To explore these ideas, participants in this study completed two tasks, a training task (ball simulation and a transfer task (a population simulation). The training task was a simulation of an oscillating ball suspended between two rubber bands and the goal was to either move the ball to the far right (maximize condition) or to have it stop between the two pins (stabilize condition), as shown in Figure 5.



Figure 5. Schematic of the training (oscillating ball) task (Day and Goldstone, p. 553)

<sup>&</sup>lt;sup>2</sup> However, relational structure only promotes transfer if people see the connection between two items without prompts, and the literature suggests that this can be problematic.



The population simulation task was described as unrelated, but was actually the transfer task, and requiring regulating the population of a city. Participants were told that the city's population would naturally vary over time as a product of media advertisements. Participants were informed that having 500,000 residents within the city would be the optimal number. Having more than 500,000 would increase crime and crowding and lower the appeal of the city, but having fewer than 500,000 would increase the appeal of the city. However, the greater the distance from 500,000, the more negative the impact on the appeal of the city. Text was presenting in a scrolling display, as shown in Figure 6.

Year 0: Population: 400000 Appeal: 0 Change in appeal: 0				View hstructions	
Year 1: Population: 442500 Appeal: 42500 Change in appeal: 42500	Goal:	To stabilize the	population	as close to	
Year 2: Population: 511563 Appeal: 69063 Change in appeal: 26563		500,000 as	possible		
Year 3: Population: 581289 Appeal: 69726 Change in appeal: 664					
Year 4: Population: 620532 Appeal: 39243 Change in appeal: -30483		Nedia	No Media	J	
Year 5: Population: 614576 Appeal: -5957 Change in appeal: -45200					
Year 8: Population: 565654 Appeal: -48923 Change in appeal: -42966					

#### Figure 6. Display for the transfer (population) task (Day and Goldstone, p. 554)

With each new piece of information, participants had to decide whether or not to use the media to influence the appeal of the populated city, based on their assigned goal.

Participants were given one of two goals, either to build the population to 1 million or to stabilize it around 500,000 (the optimal value).<sup>3</sup> Achieving these goals required using two different strategies, and the strategy used to complete the ball task was expected to inform performance on the population simulation. The tasks were argued to be governed by the same underlying principles even though they looked different. The ball task was spatial and mechanical, whereas the city task relied on numbers rather than physical space and the "forces" acting on the system were societal rather than mechanistic. Nonetheless, seeing the city as an "isomorphic physical system" was expected to show positive benefits for transfer (e.g., seeing the city's population as paralleling the position of the ball at a given moment and the city's appeal as similar to the velocity of the ball).

The primary research question was whether the strategies gained in successfully performing the ball task would transfer to performance on the population task. The primary experimental manipulation varied the goal for transfer task to be either structurally similar (i.e., requiring analogous strategies) or unique (requiring contrasting strategies) relative to the training task. Performance was expected to be facilitated when the goals of the two tasks were similar (i.e., maximizing the amplitude of both) but not when the goals of the two tasks were inconsistent (i.e., trying to maximize the ball location while stabilizing the city population or vice versa). Put another way, the mental representations created in response to analogous demands in both tasks were expected to facilitate more transfer than those formed while addressing different goals.

<sup>&</sup>lt;sup>3</sup> Participants were randomly assigned to complete one of these tasks, and completed 3 trials of the task.



Results were analysed using a 2 (goal consistency) x 2 (population task type: maximizing or stabilizing) factorial ANOVA. The first analyses focused on the time taken to complete the task, and showed a main effect for the type of test task (population stabilizing took longer than population maximizing), as well as the expected main effect for goal consistency. When the goal of the population task was congruent with the goal in the previous ball task, completion times were significantly faster. As not all participants were able to complete the population task, another analysis showed that more participants completed the population task when the requirements of the task were consistent with that of the ball task.

These effects, the authors argue, show analogical transfer between two tasks, even though there were "great dissimilarities between the two tasks in terms of their content domain, their perceptual appearance, their level of abstraction (moving visual entity versus text display), and time course (real-time interaction vs. discrete time steps)" (Day and Goldstone, 2011, p. 555). They argue that as the ball task shows continuous motion and change, and is a "concrete, spatial instantiation of the relevant principle" (p. 556), it provides a good foundation for a mental model that facilitates performance on the population task.

Several subsequent studies clarify these findings and explore alternative hypotheses. The next study showed that reversing the order of the two tasks (i.e., using the population task to train and the ball task for the transfer test) eliminated the positive transfer effects. Performing the population task first does not promote transfer because it does not afford the same ability to build a model that could be transferred to the ball task. This supports their view that the perceptual/spatial nature of the ball task promotes a better mental model.

Previous research has shown that individuals from Western societies associate movements toward the right as increasing, and those toward the left as decreasing. If this is the case, then reversing the direction required to maximize during the ball task (i.e., making it incongruent with the strategy required for the population task) could negatively affect the emergence of a mental model. This hypothesis was explored in another study that reversed the required direction for maximization in the ball task from right to left. Results showed that transfer did not occur when the direction required for maximization on the ball task was reversed, supporting the suggestion that the creation of the mental model of the ball task was disrupted by incongruence with the right-left social norms.

Other studies explored participants' perceptions about the similarity between the tasks. There is some evidence in the transfer literature that explicitly mapping the correspondences between two tasks may facilitate transfer. This suggests that participants' ability to recognize structural similarities between the two tasks might help to predict transfer. This was explored in measures completed after the two tasks were done, including open-ended questions exploring awareness of the relationship between the tasks, how similar the tasks were (and descriptions of any similarities they saw) and then a matching task in which they matched 6 defined correspondences (e.g., location of the ball would be matched with population, and direction and speed of the ball with appeal etc.). Analyses of these data showed some facilitation for participants who noticed more similarity between the tasks, but that this explicit awareness was not necessary for transfer to have occurred. Overall, then, these results are argued to indicate that explicit declarative knowledge is perhaps not sufficient for transfer, but that implicit processing may aid the acquisition of structured representations. These results, of course, run counter to a good body of transfer literature which emphasizes the role of explicit connections among analogies (e.g., Gick and Holyoak, 1983). This general finding is described by the authors as indicating that "participants appeared to be applying aspects of the appropriate strategy without recognizing that they were doing so".



As a whole, then, this research shows that performance on the transfer task was higher when preceded by a concrete simulation that was visually different but which had an analogous structure and which required similar strategies. This provides some evidence that the ball training simulation may have facilitated the formation of a mental model relevant to the transfer task.<sup>4</sup> The research showed that transfer was not linked with explicit knowledge of the relationships among the two tasks, as even people who did not report noticing explicit comparisons still showed transfer effects. This suggests that applying strategies based on mental models may lessen the need for recognition when based on a spatial and dynamic task. This research provides an important new potential link between the formation of mental models and the ability to transfer knowledge gained in one situation into another. Hopefully, future research will provide more concrete evidence of the specific role of mental models in this process.

### 4.2 Problem Representation

Kurtz and Loewenstein (2007) considered the role of problem representation and, more specifically, how problems are encoded and the subsequent impact on analogical retrieval and subsequent analogical transfer. They argue that analogical reasoning and the rates of transfer in more complex environments may be related to how information is actually encoded (i.e., the encoding of the memory probe for any given memory source), and this may impact on the process required to retrieve it. Encoding the structural features common to examples may filter out the unnecessary or irrelevant elements of particular examples. They point to research that shows the retrieval of analogical matches being more effective when the examples have generic relational content rather than concrete domain-specific content (Clement, Mawby, & Giles, 1994, cited in Kurtz & Loewenstein). This suggests that the problem of transfer is actually a representational one (i.e., they do not have the proper analogy represented in memory) rather than being related to failure to learn analogies the first time.

Kurtz and Loewenstein (2007) explain that when people form analogies that will aid transfer, it is unclear whether the schema abstraction that they perform is related to the problem setting (problem schema), solution strategy (solution schema), or to both problem setting and solution strategy. For example, if people have solved a previous problem, they can use their representation of that problem when facing a similar one. They explain that problem schemas are important for similarity retrieval as these share similar content (surface features). However, having a representation of a solution may invoke a generalized strategy for adapting and applying the retrieved knowledge, but would not typically provide a one-on-one mapping. Given this, solution schemas do not promote reliance on surface similarities, and need to be accessed by means other than similarity retrieval, such as a "temporarily heightened accessibility in memory, inclusion in a toolkit of solution strategies, or implied relevance after didactic presentation" (Kurtz & Loewenstein, 2007, p. 335).

Typical research in analogical reasoning and problem-solving, they explain, includes comparison examples associated with solutions. In theory, these comparisons should invoke schemas related to both the problem setting and to the solution strategy. However, which schema(s) (whether problem or solution centric) are actually invoked by the comparison process has never been explored. Kurtz and Loewenstein (2007) conducted three experiments to examine analogical retrieval, and the impact of comparison processes on schema development. All 3 experiments used classic analogical problem-solving materials, namely the Radiation problem, the General problem and the Red Adair

<sup>&</sup>lt;sup>4</sup> Unfortunately, the content of participants' mental models was not specifically shown in this research.



problem. Typical analogical reasoning studies ask participants to compare two source stories. This study reversed that, and instead asked participants to compare two unsolved problems.

The first study determined whether comparing two unsolved problems would invoke analogical retrieval and transfer of a previously read story analog. Participants (N=226) were separated into 3 conditions, baseline, target comparison, and source comparison. In the baseline condition, participants read one source-convergence story (the General) during the study phase, and were instructed to understand it well enough so that they could retell it later. To encourage encoding, they were also asked to generate a written response to the question: "What critical insight allowed the problem to be solved?" At the test period, they read one target problem (the radiation problem) and were asked to explain how it could be resolved. The source comparison group read and compared two source-convergence stories (the General and Red Adair). They were asked to generate commonalities and parallels between the two stories, and further asked to complete a matching task in which five elements of the stories had to be matched. During the test phase, participants in the source comparison condition read one target problem (the radiation problem), and were asked to explain how it could be resolved. In the target comparison condition, participants read the General problem (as in the baseline condition). In the test phase, however, participants read the radiation and Red Adair problems and were provided with comparison instructions that included a matching task and a hint that they could use the same strategy to resolve the problem.

Results of the first study showed that participants in both comparison conditions showed better levels of transfer than those in the baseline condition. Comparing two unsolved problems during the testing phase showed gains for analogical transfer. According to Kurtz and Loewenstein (2007), retrieval in the target comparison group could not be explained by the convergence principle (Gick & Holyoak, 1983) because performance would have been similar in the baseline condition. Rather, they argued that comparing the two story analogs fosters more effective retrieval probes for the source story and its solution.

The second study was designed to rule out an alternative account, namely that analogical retrieval was not responsible for the effects seen in Study 1, but rather that participants were directed to compare 2 targets and this might have focused their efforts and caused the effects by means other than analogical retrieval (e.g., because of instructions to compare they were encouraged to be better at problem-solving in general). The target-comparison condition was unchanged. Participants in a newly added separate targets condition were required to generate solutions to two problems, but received no instruction to compare them. Participants in the 3rd condition (targets-only) received no source story, and so were not exposed to a convergence example prior to the commencement of the testing phase..

Results were somewhat supportive of their hypotheses. Participants who were explicitly asked to compare analog stories and generate a common solution (target comparison) were more adept at solving the story analog problem than participants who were not asked to compare the two stories (separate targets condition). This finding suggests that explicit instruction is critical to fostering convergence solutions. Retrieval results were somewhat more mixed. Transfer rates between the two target groups (comparison and target-only) were only marginally higher than the separate targets condition and not different from each other. This finding, of course, was contrary to expectation. The third and final study attempted to achieve greater clarity.

Experiment 3 used the same procedures to compare transfer in the target comparison and targetonly groups. The targets-only condition had no solved source analog. As expected, results showed significantly more transfer in the target comparison condition than in the targets-only condition. Participants who read the analog story and solution and then later compared the two analog stories



showed better problem-solving performance than participants who did not read and compare the original analog story and solution. Kurtz and Loewenstein argue that these differences are likely based on their use of the initial story analog. To further determine if the findings were a specific result of analogical retrieval, participants in this study were then asked to indicate which of five possible strategy descriptions they used to resolving the problem. Data showed participants who demonstrated convergence solutions reported using an analog retrieval strategy significantly more than those who did not demonstrate convergence solutions. Participants who did not demonstrate convergence solutions reported using an independent processing strategy (i.e., solving each problem separately). Though an indirect measure, Kurtz and Loewenstein argue that verbal protocols are useful depictions of problem-solving and are used widely in psychology studies.

Based on the findings from their three experiments, Kurtz and Loewenstein (2007) concluded that comparing two unsolved story analogs at recall time promotes analogical retrieval. Further evidence showed that participants were aware that they used the analogous story for a similar solution. According to Kurtz and Loewenstein, "[t]he primary theoretical implication is that comparison-enhanced representation is effective when applied to unsolved problems at the time of test" (p. 338). They concluded that "retrieval facilitation arising from comparing source examples can be clearly attributed to the formation of a problem schema (a generalization of a problematic situation), rather than to a solution schema (a generalization of a solution strategy applicable to a range of problems)", emphasizing "a similarity-based retrieval framework" (p. 338). In terms of retrieval, Kurtz and Loewenstein found that participants do not need to learn everything about a problem in order to successfully transfer retrieved analogical knowledge by abstracting structural matches otherwise concealed. They also suggest that given that the schema is the probe and is involved in all comparisons in contrast to a stored schema, target comparison "offers the promise that ordinary experience need not be analogically inert" (p. 338).

Kurtz and Loewenstein (2007) – Study 3 only		
Methodology Used	Problem solving	
Source/Cue/Training	Target comparison – asked to read General problem Targets only – no General problem provided	
Target/Test/Outcome	Target comparison – Radiation and Red Adair problems with instructions to compare Targets only - Radiation and Red Adair problems with instructions to compare	
Independent Variables	Presence (target comparison) vs. absence (target only) of the initial convergence story	
Dependent Measures	Rate of convergence solutions Ratings of strategies used by participants	
Findings	Comparison-based representation is effective when applied to unsolved problems at time of test	

Research by Gentner, Loewenstein, Thompson and Forbus (2009) explores exactly how comparison promotes future transfer. One of the key problems with analogical transfer, they argue, is that although it can promote insight, is often fails to occur. This is described as the inert knowledge problem, emphasizing the fact that people who apparently have relevant knowledge are not always able to access it.



As noted throughout this section, using comparison is argued to be one way to promote higher levels of transfer, but this research explores exactly how this might occur. They argue that there at least 2 possible theoretical accounts of how comparison might promote transfer, and they advance two different accounts related to <u>relational schema abstraction</u> and <u>learning-to-encode</u>.

The <u>relational schema abstraction</u> account argues that comparing two examples simultaneously puts emphasis on relational structure rather than on idiosyncratic or surface features<sup>5</sup>, allowing extraneous details to be eliminated from the picture. This results in a relational schema stored in memory that is "a fairly concentrated relational representation, with many of the initial itemspecific features stripped away" (p. 1345). The result, this account argues, is that any future examples encountered will be better represented by the relational schema, and this will facilitate transfer.

The learning-to-encode account also implicates the importance of "relational highlighting" but argues that transfer is facilitated by changes in how future examples are encoded, rather than because of stored abstractions (as in the relational schema account). More specifically, this account argues that comparison processes facilitate uniformity in processing and can result in "relational insights" that promote better processing when encountering a relevant new object. These relational insights are argued to promote more transfer. The learning-to-encode account is the more parsimonious, as its account of analogical transfer does not depend on the existence of schemas.

These two accounts, Gentner et al. (2009) argue each make testable predictions that they explored in a series of studies. The learning-to-encode explanation is predicated on the assumption that how people encode information naturally changes as they acquire more expertise. This account, "naturally predicts the inert knowledge effect because it predicts low overlap between new encodings and old encodings made prior to the analogical insight" (p. 1345). According this account, then, understanding the overlap between old and new encodings would provide evidence relevant to the validity of the "learning to encode" account.

On the other hand, the relational abstraction account argues that once developed, a schema will differ from a new example in two primary ways. First, it will have fewer surface features that do not match, and the relations that it describes will gain more weight. Moreover, relational schemas should be equally effective as either a probe or as a memory item. This means that these schemas should facilitate both forward transfer and "backwards" relational retrieval, or what they also call "late analogical abstraction". More specifically, their major assertion is "that the schema resulting from comparing two analogs will increase relational retrieval whether it serves as a memory item (leading to transfer forward in time) or as a probe (leading to retrieval backwards in time)" (Gentner et al., 2009, p. 1346). These ideas were tested in 4 studies and a simulation. The first 3 studies relied on memory for personal life events.

Experiment 1 explored both forward relational transfer and backward relational retrieval and relied on management consultants with work experience. Participants received two case studies of negotiations. Half of the participants were asked to compare them and half to study them one at a time. All were required to produce written descriptions answering questions about the case studies they had read (e.g., "What is going on in this/these negotiations?" p. 1348). The quality of the case

<sup>&</sup>lt;sup>5</sup> On the other hand, when people study single cases (without the ability to compare them to others), "they tend to encode them in more concrete, context-specific manner, with the result that later remindings are often based on surface similarities" (Gentner et al., 2009, p. 1344).



descriptions produced was taken as a representation of the participants understanding of the underlying principles (see "Schema" bars in Figure 6).

To explore relational retrieval, all participants were then asked to recall an example instantiating the principle they had just read about, and to identify the source of the example (own experience, colleagues, etc.; see "Retrieval" bars in Figure 6). (Both case descriptions and recalled examples were coded by experimenters.)

Participants were then paired and completed a face-to-face negotiation, set in a different context than the training cases. The ability to form a contingent contract with their partner (or not) was the measure of knowledge transfer, in combination with a coded-for-quality written description of their negotiation (see "Transfer" bars in Figure 7). Means for each of these 3 indicators are shown in Figure 6.



Figure 7. Study 1 results (Gentner et al., 2009, p. 1350)

As expected, participants required to compare the case studies (rather than reading them separately) performed better on all 3 measures, as shown by the black "Compare" bars in Figure 6.

Starting at the left side of the chart, forming schemas (i.e., knowledge of the underlying principles) was more effective when comparison was used.

Results for the retrieval measures show evidence of backward relational transfer. The ability of participants in the comparison group to retrieve good examples of contingent contracts based on their past experiences (relational retrieval) suggests that abstract representations provided better ability to match prior examples of the contingency contract. This finding is consistent with the relational schema abstraction account, and argues against the learning-to-encode account, which would predict no such advantage. The second experiment replicated these retrieval results with a less expert sample of participants (namely, Masters of accounting students presumably with less experience creating contracts).

The third experiment expanded the set of negotiation strategies in play by introducing a trade-off strategy as well as the contingent contract strategy. A control condition in which participants read just a single case study was also added to ensure that the advantages of comparison did not simply stem from poor performance in the separate cases condition. Results showed that participants who compared cases (whether contingency or trade-off scenarios) better captured the principles underlying the cases (evidence for more developed schemas), and retrieved analogical matches



from their past memories more proficiently than participants not comparing cases (either separate case or single case).

As a whole, this series of studies argues that analogical abstraction can have two different impacts depending on the active cognitive stage. At the time of learning, analogical abstraction can promote transfer to future exemplars. At the retrieval stage, comparing two objects (even after initial learning has occurred) can help to access existing exemplars in memory (i.e., late analogical abstraction).

Gentner et al. (2009) – Study 3 only		
Methodology Used	Contingent contracts approach	
Source/Cue/Training	Case studies describing contingency contracts examples and trade-off examples	
Target/Test/Outcome	Simulated test negotiation	
Independent Variables	Comparison condition (Contingency contract or trade-off), separate-case condition (read 2 separate cases) or control condition (read 1 case)	
Dependent Measures	Questionnaire - type of solution reached, similarity to training cases, linking of cases, suggestion of ideal settlement Experimenter coding of participant case descriptions and retrievals – rating of whether they described contingency contract principles or trade-off principles	
Findings	Participants in the comparison conditions (contingency and trade-off) showed better grasp of principles than those in control conditions, and better than those in the separate-case group They were also more likely to retrieve a relational example, and the quality of their case descriptions were significantly correlated with their retrievals	

Table 10. Gentner et al. – Study 3 (2009)

The research described in this section emphasizes the importance of comparison processes in facilitating transfer, and this is described in terms of either surface similarity or deep relational structure (i.e., structural similarity). As noted earlier, structural similarity is argued to be a more effective aid to transfer than surface similarity.

### 4.2 Discussion

This chapter examined the nature of transfer from a traditional cognitive perspective. The research reviewed in this chapter works to understand the role of analogical reasoning in transfer. This body of research focuses on the key learning and generalization processes that are relevant to transfer. Conceived from this perspective, transfer is understood primarily as analogical reasoning, and includes encoding, inference, mapping, application and response. The key questions in the literature revolve around how these processes are actually manifested in analogical reasoning.

Established researchers in this area suggest that analogical transfer can be very powerful when it occurs (e.g., Gentner et al., 2009). When people can access the required example, they are often very adept at mapping this solution to the problem at hand. For example, there are notable examples of spontaneous transfer in the literature (e.g., Gentner, Ratterman and Forbus, 1993). (Blanchette and Dunbar, 2000).

On the other hand, researchers have also noted that when attempting to abstract from a single case to a new environment or context, transfer can also be a very elusive event (Gentner et al., 2009).



Literature reviewed in this chapter (e.g., Gick and Holyoak, 1980, 1983) shows that when in a new situation, people often fail to access information they have available to them from their previous experiences. One of the problems noted in the analogical literature is that people seem to have trouble solving a problem that is analogous to one already (and recently) solved, when the problem is similar but comes from a different context (Thompson et al., 2000, p. 61).

Understanding the often elusive nature of transfer can only be attained through consideration of the roles of both surface and structural similarity. There is very good evidence that in some situations, people rely on surface similarities when using analogies for transfer. This is consistent with the finding that generalization is furthered by the provision of concrete examples when learning source material, in part because these invoke surface features, which have been shown to summon source material more readily than structural similarity (Chen et al., 1995).

The stage of cognition at play within the surface and structural similarity accounts varies (Blanchette and Dunbar, 2000). Superficial similarity is primarily associated with source access and retrieval (Sternberg's encoding phase), whereas structural similarity is primarily associated with the mapping and evaluation phases of analogy (Sternberg's inference and mapping phases). This body of research understands transfer as a psychological phenomenon involving the creation of symbolic representations of learning and transfer situations.

The available literature also suggests a core irony about the roles of surface and structural similarity in analogical reasoning. When considering the soundness of a similarity match between two analogs, people favour shared relational structures over surface features and have a greater tendency to recall surface features at time of test (Gentner et al., 1993). Gentner et al. (2009, p. 1344) argue that "most remindings to prior situations appear to be driven largely by surface similarities, such as similar characters and settings, rather than by similarities in relational structure". These can be labelled as "failures of relational transfer" or of relational retrieval (Gentner et al., 2009). This means, of course, that some sort of relation has been learned, but that it is not retrieved at the time and in the required form when in a new situation. This may be because even if people have better information at hand, they may tend to rely on surface similarity rather than structural similarity because this is what they can retrieve. When presented with both types of similarity information, people have been shown to regard structural similarities to be more useful for reasoning. Thompson et al. (2000, p. 62) alludes to an ironic reality for transfer:

"...these results point to a striking dissociation between what is accessible in memory and what is most useful in reasoning: We often fail to recall what is ultimately the most valuable for solving new problems..."

An important implication of this is that analogical transfer is likely to be most problematic when new situations require the application of more complex causal principles. Unfortunately, this is the context in which much dynamic decision-making at the team level must occur.

There is also very good evidence in the literature that "the best-established way of promoting relational transfer is for the learner to compare analogous example during learning" (Gentner et al., 2009, p. 1344). The analogical reasoning research reviewed in this chapter shows that when asked to compare two or more source analogs (Gick & Holyoak, 1983; Gentner et al., 2003; Kurtz & Loewenstein, 2007) or to generate their own source analog (Blanchette & Dunbar, 2000) individuals can generalize structural features (including first- and higher-order principles) of source analogs to target analogs. Research has shown that when asked to produce analogies, people tend to use structural similarities (optimal schema abstraction) rather than superficial similarities more frequently (Blanchette & Dunbar, 2000). As Gentner et al. (2009, p. 1344) argue, "comparison can



lead learners to focus on deep relational commonalities rather than on specific, potentially idiosyncratic features of the particular examples". There is also some evidence in the literature that one of the reasons why analogical comparison can be effective is that it can facilitate the emergence of a schema that links deep structural relations into a somewhat more coherent whole. The development of a schema might facilitate the ability to use the schema when encountered with a structurally similar problem. This is particularly likely to happen when these source analogs provide good quality schemas of the learned material (Novick & Holyoak, 1991; Gentner et al., 2003;), or when schemata are induced and then utilized in problem-solving tasks (Gick & Holyoak, 1983) and when they can be adapted to novel situations (Lerda et al., 1996). The power of an activated schema has led some to ask whether an abstract representation is necessary for mapping knowledge gained in source to target (e.g., Mondoux, 2004). Loewenstein et al. (2003, p. 120) argue that "Case comparison encourages appropriate analysis, inspires curiosity, and leads to abstracting principles." However, there is also a sense in the literature that people may also be unlikely to make comparisons unless they are specifically instructed or otherwise required to do so.

Newer research extends beyond comparison processes to show the potential value of mental models in promoting transfer from one situation to another (Day and Goldstone, 2011). When provided with a model of a spatial challenge that can be met through use of a specific strategy, using principle-based reasoning can promote the ability to transfer this knowledge from one challenge to a very different one by relying on a similar strategy (based on the mental model formed while completing the first task). This research showed that transfer did not occur when the emergence of a mental model was stifled in some way (e.g., reversing the direction of the required strategy). Hopefully, future research will more fully help to elaborate the potential role of mental models in analogical transfer as well as being extended to explore transfer in the team domain.

This line of research presents very rich information about the nature of transfer, and benefits from its use of very tight experimental designs and offers a high degree of experimental control. This suggests that these designs will help to elucidate exactly how the process of transfer might occur, an issue that seems to have received less attention in the transfer of training literature. However, the low fidelity of some analogical approaches may limit the generalizability of the findings in that body of research. This suggests that the highest possible level of fidelity should be sought to understand analogical transfer. For example, one approach that seems to have a high level of generalizability is the contingent contract approach. A common feature of the contingent contract methodology is that there is a separate condition and a comparison condition. After learners are required to analyze each case, measures are taken of the degree to which they used the strategy implied by the training case when conducting a subsequent negotiation.

Of course, understanding transfer from a purely cognitive perspective has also been criticized. Critics argue that the purely cognitive approach to transfer detaches it from the overall training/learning context. Other approaches (e.g., actor-oriented approach) emphasize the potential spread of transfer across social, mental and even cultural planes. Despite the contribution of the analogical research to understanding transfer, additional factors such as trainee characteristics (e.g., personality and motivation), training design factors, and work environment factors may help broaden the investigation of the learning and transfer process. Some of these factors are considered in more detail in the transfer of training research presented in Annex B, and within the relevant team adaptation and transfer research presented in the chapter that follows.



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## 5. Team Adaptation and Transfer

The previous sections of this report have explored the transfer literature in terms of cognitive processes, and from the industrial/organizational perspective. This chapter explores transfer within teams. The concept of team adaptation is given particular attention as a construct that might help elucidate the issue of how teams transfer their training during collaborative efforts.

It seems important to make a distinction between literature that speaks directly to transfer within teams, and the vast team training and performance literature. For the purposes of this review, improvement in performance as the result of training does not necessarily indicate transfer – only when this training is actually used on a somewhat different task within an at least somewhat new environment has formal transfer occurred.

## 5.1 The Concept of Team Adaptation

The available literature suggests that working as a team can facilitate better learning and/or transfer. A critical issue is the extent to which teams are able to acquire and use knowledge better within a team environment rather than as individuals. For example, research by Schwartz (1995; cited in Loewenstein et al., 2003) is reported to have shown that a pair of learners was more able to grasp a schema based on a single example than were individual learners. This finding was attributed to the partners "fleshing out each other's understandings" (Schwartz, 1995; cited in Loewenstein et al., 2003, p. 121). On the other hand, the team literature also provides clear examples of how the team environment can hinder rather than promote learning and performance (Jones & Roelofsma, 2001). The critical issue at hand, however, is how transfer of training can best be facilitated within teams.

As noted earlier, within the generic transfer literature, researchers construe transfer as requiring the generalization of some kind of knowledge and skills beyond a learning context to another, new context (Baldwin & Ford, 1988; Lobato et al., 2003). Within the team literature, team adaptability seems to be defined in ways that are very similar to transfer of training. For example, Kozlowski, Toney, Mullins, Weissbein, Brown, and Bell (2001, p. 107) define adaptation as "[t]he generalization of trained knowledge and skills to new, more difficult, and more complex task situations". Adaptability, like knowledge or skill transfer to novel situations, sometimes requires innovative (Bransford & Schwarz, 2002) and flexible (de Croock & van Merrienboer, 2007) behaviour as a precursor to transfer. LePine's (2003) and Kozlowski, Gully, Nason, and Smith's (1999, cited in Burke et al., 2006) definitions of team adaptation both include some degree of innovation. LePine defines team adaptation as "reactive and nonscripted adjustments to a team's system of member roles that contribute to team effectiveness" (2003, p.28). Kozlowski et al. (1999, cited in Burke et al., 2006) define adaptation as the "capability of the team to maintain coordinated interdependence and performance by selecting an appropriate network from its repertoire or by inventing a new configuration. Thus, adaptability refers to "a metamorphic shift in the team network in the short term to deal with the performance demands of a nonroutine task". Similar to Bransford and Schwarz's (2002) definition of transfer, these definitions suggest that teams must react and make suitable adjustments in response to novel settings to accomplish "nonroutine" tasks. Teams that encourage innovative thinking as part of the process may foster greater transfer in adapting to novel situations. Moreover, it is also commonly recognized that "....the generalization component of training transfer is more critical when considering complex, unpredictable and dynamic posttraining environments" (Kozlowski et al., 2001, cited in Chen,



Thomas et al., 2005, p. 828). The ability to generalize one's training relies on the emergence of adaptive expertise (Smith, Ford and Kozlowski, 1997), namely the ability to change knowledge, skills and other qualities in order to adapt to novel situations. For example, studies within this domain often define transfer as the extent to which teams are able to change their communication structures, task structures, and strategies in order to sufficiently meet the demands of a dynamic situation or task (e.g., Kozlowski, Toney, Mullins, Weissbein, Brown, & Bell, 2001; LePine, 2003 cited in Burke et al., 2006). Similarly, transfer within teams has also been equated with the term "team adaptive performance" (e.g., Chen, 2005).

The following section explores the link between transfer and team adaptation in more detail. To this end, we provide an overview of Burke and colleagues' (2006) model of team adaptation, as it is the most concentrated available theoretical discussion about the team adaptation construct. Following this, we discuss the most recent studies investigating team adaptation. And finally, we describe the available literature relevant to team training mechanisms (specifically cross-training, team coordination, and adaptation training) that are meant to promote team adaptation and effectiveness. These interventions are potentially relevant to transfer of training within a team context.

Before settling on a specific definition of team adaptation, Burke and colleagues (2006) examined a number of definitions from a variety of disciplines in order to ensure that their definition of adaptability was holistic and reflected the individual, team, and organizational levels, as shown in Figure 8.

Date of origin	Authors	Definition
1995	Cannon Bowers, Tannenbaum, Salas, & Volpe	The process by which a team is able to use information gathered from the task environment to adjust strategies through the use of compensatory behaviors and reallocation of intrateam resources
1999	Kozlowski, Gully, Nason, & Smith	Capability of the team to maintain coordinated interdependence and performance by selecting an appropriate network from its repertoire or by inventing a new configuration. Thus, adaptability refers to a metamorphic shift in the team network in the short term to deal with the performance demands of a nonroutine task.
2001	G. Klein & Pierce	Teams that are able to make the necessary modifications in order to meet new challenges
2001	Kozlowski, Toney, Mullins, Weissbein, Brown, & Bell	The generalization of trained knowledge and skills to new, more difficult, and more complex task situations
2003	Fleming, Wood, Dudley, Badeı, & Zaccaro	Functional change in response to altered environmental contingencies and a higher order process that emerges from an integrated set of individual attrbutes
2003	LePine	Reactive ard nonscripted adjustments to a team's system of member roles that contribute to team effectiveness
2004	Merrian-Webster OnLine	The act or process of adapting or the state of being adapted

#### Figure 8. Definitions of adaptability and adaptation (Burke et al., 2006, p. 1191)

For Burke et al. (2006, p. 1190), team adaptation is "a change in team performance, in response to a salient cue or cue stream, that leads to a functional outcome for the entire team". This change can be "manifested in the innovation of new or modification of existing structures, capacities, and/or behavioural or cognitive goal-directed actions". According to Burke and colleagues, teams are able to overcome obstacles by forming or manipulating existing structures within a task (such as a cognitive schema or inter-member communication). This functional outcome of team adaptation is a realignment of performance which improves how the team operates and/or achieves objectives. Moreover, the functional change is made in order to maintain the existence of the team or to develop the larger whole in terms of growth and capability (Burke et al., 2006). Team adaptation is conceptualized and measured at the holistic team level.



Before fully elaborating their model of team adaptation, Burke and colleagues (2006) describe and distinguish three constructs that are similar to team adaptation but distinct from it, including team learning, team innovation, and team problem management. First, citing Edmonson (1999, cited in Burke et al., 2006), they describe team learning as a process by which team members obtain knowledge through testing and evaluating assumptions, beliefs, procedures, behaviours, and by forming new methods and strategies to adjust to inadequate or erroneous behaviour or new or changing situations. Burke et al. argue that engaging in these activities helps teams develop collective understanding of any given situation. The resulting behaviour helps teams identify changes within their environment. Team learning may provide understanding of necessary knowledge transformation, shared mental models, and cognitive schema that contribute to increasing the behaviour repertoire of a team (LePine, 2003). However, unlike team adaptation, team learning is a latent construct and may never be fully realized (Burke et al., 2006). Unlike team learning, then, it is necessary to actually exercise knowledge or learning for team adaptation to occur.

Burke et al. (2006) also suggest that team innovation is distinct from team adaptation. Team innovation is a process by which teams create, produce, and implement new ideas to improve team processes and team performance (Burke et al., 2006). Innovation inputs and new knowledge inputs transform the team's cognitive schema, helping teams to adapt. Like adaptation, innovation is purposeful and iterative, and supports the teams' cognitive and behavioural goal-directed actions. However, as Burke et al. explain, some level of innovation may act as a precursor for team adaptation to occur. However, it differs from adaptation because it is typically understood as a process rather than an outcome and does not necessarily lead to a functional outcome (i.e., a realignment of performance) as required for team adaptation.

Finally, Burke et al. (2006) include team problem management as a third construct, which shares elements with team adaptation but is also distinct from it. Team problem management refers to the process of addressing potential or actual problems, errors and obstacles proactively. Burke et al. explain that teams exercise problem management to identify, mediate, and manage obstacles that hinder team performance and effectiveness. However they argue that team problem management does not necessarily require team adaptation for high level functioning. All three constructs briefly described above have similarities with team adaptation, but according to Burke et al., should not be confused with team adaptation.

In further developing their understanding of team adaptation, Burke and colleagues (2006) constructed a conceptual model, including four core constructs that characterize the adaptive cycle process that ultimately leads to team adaptation. This model is shown in Figure 9.





#### Adaptive Team Performance

#### Figure 9. Input-throughput-output model of team adaptation (Burke et al., 2006)

Looking at the right side of Figure 12, team adaptation is the outcome of a complex adaptive cycle, as well as being influenced by characteristics of the individual and the job. At its core, team adaptation is argued to be a change in team performance manifested in "the innovation of new or modification of existing structures, capacities, and/or behavioral or cognitive goal-directed actions" (Burke et al., 2006, p. 1190).

The phases of the team adaptive cycle include situation assessment (cue recognition and meaning ascription), plan formulation, plan execution (coordination and leadership), and team learning.

In the first phase of situation assessment, the adaptive cycle begins with cue recognition which is initiated at the individual level, as team members scan the surrounding environment to identify anything that could impact the team's performance and success. Once a cue has been identified, individual members activate existing knowledge structures (i.e., mental models and schemas) in efforts to understand the cue and to ascribe meaning to it. After a team member assesses the situation, they communicate this information to their team. In turn, individual mental models and situation awareness of all team members are influenced thus developing mental models and situation awareness at the team level.

Once the cue recognition process has been fulfilled and teams recognize the need for change, they move to the plan formulation phase. Citing Stout and Salas (1993), Burke et al. (2006) highlight a number of factors that go into planning, such as choosing a course of action, setting goals, clarifying member roles and responsibilities, discussing environmental characteristics and



constraints, prioritizing tasks, establishing performance expectations, and sharing task related information.

Once the plan is developed, it is then executed. As Burke et al. (2006, p. 1195) explain, "plan execution involves an assortment of concomitant individual- and team-level processes that are enacted dynamically, simultaneously, and recursively". Individual level behaviours include mutual performance monitoring, backup behaviour, communication and leadership, with coordination representing a team level process. For example, communication is vital to the adaptive cycle as it allows a team to share information, update shared knowledge structures, and steer adaptive behaviours. Burke et al. argue that the success of adaptive plan execution depends on teams exhibiting these behaviours and leadership. Interestingly, leadership is given a key role in team adaptability, as a leader can help promote the conditions that promote better teamwork and coordination. The ability of teams to utilize "shared leadership" is also indicated as strengthening adaptability. Specifically, when leadership roles need to shift, shared knowledge structures among team members (e.g., shared mental models and specifically team mental models) are argued to reduce the demands of leadership change and ensure a smoother transition.

The final phase of the adaptive cycle is team learning. Team learning is an evolving process where team members seek information, reflect on input, elicit feedback, and discuss both positive and negative outcomes of team action (Edmonson, 1999, cited in Burke et al., 2006). Learning occurs when the team understands the consequences of their previous actions and how to prevent or replicate these outcomes in the future. Team learning promotes team knowledge so that the team can be better prepared to scan their environment for future changes. Team learning involves the development of a shared mental model or schema about the task. The transfer and the transfer of training literature argue that the comparison process facilitates development of a schema of the task which then guides the ability to generalize. Using comparison to strip away some of the non-common attributes allows a clearer vision of the underlying structure of the analogy to emerge and promotes transfer. Generalization to a different task and/context, then, will require the ability to recognize the new situation being faced as a team and to make the necessary adjustments within the team to deal with these differences.

Also identified in the model are the emergent cognitive states (i.e., the cognitive, motivational and affective states of the team) (Marks, Mathieu, & Zaccaro, 2001, cited in Burke et al., 2006), that arise and vary throughout the adaptive cycle. These emergent states include shared mental models, team situation awareness, and psychological safety which feed into the adaptive cycle. According to Burke et al. (2006), these process variables describe the nature of team interaction within the adaptive cycle.

The individual characteristics of team members are argued to influence the adaptive cycle. According to Burke et al. (2006), to be adaptive, team members must have specific knowledge, consisting of task expertise, team expertise and mental models (see Figure 12). Task expertise refers to an individual's familiarity of a particular task and how it relates to the overall situation. Team members with task expertise know what to do, how to do it, and why it needs to be done. Team expertise is also important for adaptation. For example, team members recognizing that another team member is not performing to the best of his or her ability can provide the required backup behaviour in order to adapt to the situation. For Burke et al., recognizing the cues in the environment that signify change requires a deep understanding about other team members (e.g., expertise, knowledge about the tasks and the team roles and responsibilities). This will be further enhanced if individual team members hold accurate and flexible mental models (i.e., dynamic, cognitive representations of the world that people use to describe, interpret and predict events).



Burke et al. argue that these knowledge structures should promote strong situation awareness, thereby assisting the adaptive cycle.

Other individual characteristics that will contribute to situation assessment include team orientation, openness to experience, and general cognitive ability. According to Goodwin, O'Shea, Driskell, Salas and Ardinson (2004, cited in Burke et al., 2006), team members with a strong team orientation attitude tend to work well with other people, ask for input, contribute to the team, and enjoy being part of a team. This attitude may promote adaptation. Research also suggests that individuals with high openness to experience are less likely to become hardened in routine and accept novel solutions to problems more readily (LePine, Colquitt, & Erez, 2000, cited in Burke et al., 2006). As noted earlier, evidence suggests that individual team members with high cognitive ability adapt more than team members with low cognitive ability (LePine et al., 2000, cited in Burke et al., 2006).

In addition to individual characteristics, job design characteristics are said to influence the adaptive cycle, specifically at the plan development phase. Under job design characteristics, Burke et al. (2006) identify team self-management as important to adaptation. Team self-management can be defined as the amount of decision and management control that a team has over itself and its actions. Team self-management can be a result of adaptation as well as an antecedent. For example, teams that show their effectiveness and adaptation may receive more power to make decisions within the team.

In sum, team adaptation occurs when the team identifies a cue pattern that represents some degree of misalignment in the team's performance and the demands of the team's task outcome (Burke et al., 2006). Correcting this misalignment is the result of the adaptive cycle. As well, Burke et al. (2006, p. 1201) argue that the development of team members' task expertise is a "secondary indicator of team adaptation". Team adaptation can be viewed longitudinally, as baseline team performance levels can decline because of misalignment and then increase as a result of adaptation (i.e., realignment of team performance) (Burke et al., 2006). Burke et al. suggest that this can be measured by plotting a team's performance as a function of time.

Entin and Serfaty (1999) also emphasize the importance of adaptive team coordination. They argue that teams are able to manage high stress situations when they have the ability to adapt their processes and strategies. Specifically, they note the importance of increases in information seeking evidenced in previous research (LaPorte and Consolini, 1988; cited in Entin and Serfaty, 1999), that indicate the shift from explicit coordination to implicit coordination. Implicit coordination, they note, is often argued to be dependent on the use of shared mental models of the task and of team member functions. They present a model showing the critical factors in team adaptation as shown in Figure 10.





#### Figure 10. Theoretical model for team adaptation (Entin and Serfaty, 1999, p. 314).

This model emphasizes 3 key aspects of team adaptation, which are shifts in the decision-making strategies of the team to adapt to the situation, coordination adaptation and structural reconfiguration. These elements work to either minimize stress or to promote the maintenance of team performance.

Entin and Serfaty assert that highly adaptive teams are better able to recognize and manage stress by shifting some combination of the 3 key elements in order to either reduce stress or to maintain performance. Moreover, they argue that team adaptation and coordination training makes a significant contribution to team adaptability because it teaches team members the signs of stress and means by which to adjust their strategies. Although relevant to the discussion of team adaptation, however, this model does not explicitly seem to address the issue of transfer within teams.

A model by Kozlowski and colleagues argues that self-regulatory processes are the basis of learning, motivation and performance, and they posit the Adaptive Learning System (ALS) model (Kozlowski, Toney, Mullins, Weissbein, Brown, & Bell, 2001). Although this model was intended to guide the design of "integrated-embedded training systems" rather than to specifically address the relationship between team adaptability and transfer, it does offer some relevant insights into this relationship. Self-regulatory processes have been argued to be critical to performing complex tasks, and require "monitoring the differences between goal states and current states. Negative discrepancies induce self-evaluation and, depending on affective reactions and causal attributions, reallocation of attention and effort to move closer toward goal accomplishment." (Kozlowski et al., 2001, p. 64). This model depicts transfer as being influenced by 5 sets of factors, as shown in Figure 11.





Figure 11. Adaptive learning system model (Kozlowski et al., 2001, p. 65)

First, characteristics of the trainee (including both inherent abilities and dispositions) impact on 3 aspects of the Active Learning System. Cognitive abilities have been shown to be positively associated with training performance (Schmidt, Hunter, Outerbridge and Goff, 1988; cited in Kozlowski et al., 2001) and general learning ability. Motives such as goal orientation are also argued to influence adaptive learning. People can be focused either on mastery (learning for the sake of learning) or on performance-based learning (learning aimed at demonstrating one's competence).

The components of the Active Learning System include training components, the mode of training instruction and the nature of the self-regulatory system in play. Training components relate to the design of training information and practice (e.g., simulation scenarios), to the provision of feedback, and to how trainees perceive the training experience (e.g., motivation and attributions). Self-regulation is argued to be an issue because it determines how individuals respond to the challenges that they face. This includes how they interact with training (practice or behaviour), how they attend to and reflect their on training progress (self-monitoring or cognition), and how they react emotionally to it (self-evaluation or affect). The ALS leads to performance outcomes associated with the specific training task (low complexity transfer), as well as more distal outcomes that represent complex transfer, retention of the knowledge and skills and adaptation of these to a different task.

It is important to note that this model showing team adaptation within the training context is consistent with many of the factors noted in other transfer of training research (e.g., cognitive abilities/skills, motivation, etc.). This model specifically posits a link between adaptive learning and transfer. However, although it describes the hypothetical relationships among the many constructs, it offers no specific information about the exact nature of transfer and provides no test of this model. The next section describes empirical research investigating team transfer of training and team adaptation.



## 5.2 Relevant Team Research

The model presented by Burke and colleagues (2006) provides a foundational understanding of how critical factors such as task and team expertise, leadership, and attitudes (orientation) may influence team adaptation. The team literature explores a number of these factors, including attitudes (e.g., team or goal orientation), team learning and team knowledge, and leader support. The sections that follow explore these factors as well as the theoretical constructs relevant to team adaptation.

Research by Loewenstein, Thompson and Gentner (2003) presents perhaps the most relevant research to understanding analogical transfer within the team context. This work used the contingent contract methodology to explore analogical reasoning in teams. Interestingly, the researchers did not make any predictions about the impact of having teams (rather than individuals) undertake analogical reasoning, because they argued that the literature is unclear on whether this would offer advantages or disadvantages. On one hand, they argue that teams may have more "attentional capacity" and may "share more information" than individuals. There is also evidence that team learning can be synergistic. On the other hand, they noted that there is also good evidence in the literature that teams can also have decreased performance because of social and cognitive factors (e.g., competition rather than cooperation). As such, they made no specific predictions.

Teams of managers and management students (n = 270) were asked to analyze training cases in a <u>baseline condition</u> (receiving no training), a <u>separate-case team training condition</u> and a comparison-case team training condition. The second independent variable (totally crossed with the first) was whether negotiations were performed as individuals (solo – dissolved team) or team (intact team). The primary dependent measure was whether contingency contracts were successfully formed or not. Another measure explored the joint expected value of these contracts. Each of these last 2 measures was derived from coding of respondents descriptions of the resolution of the negotiation.

The two experimental groups received 2 training cases describing a conflictual negotiation situation. All participants were given 20 minutes to read and discuss the cases with their randomly assigned teammate. Participants in the separate-cases condition analysed one case at a time, responding to the probes "What is going on in this negotiation? Please describe the solution and say how successful you think it is" after reading *each* case. Teams in the comparison-case condition were asked to compare the two cases, and given the following instructions "What is going on in these negotiations? Think about the similarities between these two cases. What are the key parallels in the two negotiations? Please describe the solution and say how successful you think it is." Participants worked as a team to provide written answers to these questions. In the transfer task, participants then completed a face-to-face negotiation as either part of team or as individuals.

Results showed that negotiation performance (as measured by the formation of contingent contracts) was better with analogy training (i.e., instructions to compare cases) than without. Teams in the comparison condition showed a higher rate of forming contingent contracts than those that read separate cases. Comparison training groups showed significantly better performance than no training baseline groups, but separate case training groups did not.

In terms of how the negotiation was actually undertaken, participants in the comparison group who negotiated separately showed significantly better face-to-face negotiation performance than participants in the baseline group and did not differ significantly from the separate group. Combining comparison and separate case groups, there was no effect of negotiating in intact teams vs. solo. However, again collapsing across negotiation performance and training context, teams in



the comparison groups created twice as many contingency contracts as in baseline and separate case conditions. This suggests that the process of drawing comparisons did facilitate learning and application to the target task (face-to-face negotiation). Other analyses of the joint value variable showed that comparison group participants generated higher value contracts than separate case and baseline participants (who did not differ from each other).

Coding of the team reports showed that participants drawing comparisons showed more evidence of schema induction than those who analyzed cases on their own. This suggests that comparisons may have facilitated understanding of more of the underlying principles in the cases.

Loewenstein et al., 2003		
Methodology Used	Contingent contracts	
Source/Cue/Training	Training cases about negotiations	
Probe/Test/Outcome	Face-to-face negotiation	
Independent Variables	Training condition – Evaluate cases one at a time vs. evaluate using comparison "What is going on in this negotiation? Please describe the solution and say how successful you think it is." "What is going on in this negotiation? Think about the similarities between the two cases. What are the key parallels in the two negotiations? Please describe the situation and say how successful you think it is." Negotiation condition – team vs. solo	
Dependent Measures	Coded analysis of responses training cases (written) Outcome of negotiation (coded) Joint value of negotiation (coded)	
Findings	Comparison facilitates transfer through emergence of schema Comparison within teams showed no advantage – individuals better than teams with comparison Comparison better than evaluating separately on all dimensions – better negotiation outcomes – more joint value Evidence of schema formation in comparison group when describing training cases	

### Table 11. Loewenstein et al. (2003)

Consistent with the analogical reasoning research at the individual level, this research again shows the advantages of using comparison at the encoding stage, and that this promotes better transfer to the target task. On the other hand, working in a team when doing analogical comparison did not appear to offer any advantages. In fact, participants who analyzed cases on their own performed better. The researchers argue that this could be because mere information exchange on its own may not be conducive to better contingent contracts. This suggests that it would be critical to understand exactly how teams should be encouraged to undertake comparison in order to promote better levels of team transfer. However, it is also possible that the task used in this research may not have been sophisticated enough to engage team processes. If this was the case, a more complex team task requiring collective effort may have shown team transfer effects.

Research by Chen, Thomas and Wallace (2005) offers a unique multi-level analysis of the factors that influence team performance. This research compared the impact of a range of outcomes (e.g., cognitive, affective-motivational, and behavioural training outcomes) on regulatory processes that occurred after training and adaptive performance, focusing on potential differences between



individual and team levels. These authors argued that simultaneous analysis of both levels was lacking in the existing literature. This work also makes a distinction between goal choice and goal striving. Goal choice refers to the decision to give specific attention to one part of a task (over another part of the task). At the team level, goal choices are represented in a range of transition phase processes involving activities such as planning, goal specification, and mission analysis. Goal striving, refers to "...actually allocating and sustaining effort in the pursuit of goal accomplishment" (Chen et al., 2005, p. 830). At the team level, action phase processes include activities such as monitoring progress toward goals, system monitoring, team monitoring and backup behaviour and coordination. However, goal choice and transition processes are argued to occur between episodes, while goal striving and action processes influence performance even during training episodes.

This research posited that knowledge, perceived efficacy and skill all work to determine the processes and activities that are enacted at both the team and individual levels. These, in turn, determine performance, as shown in Figure 12.



# Figure 12. Multilevel model of training and adaptive performance (Chen et al., 2005, p. 828)

A number of specific hypotheses were explored. First, they expected that the within-episode processes would fully mediate the impact of the transition processes on performance. The second hypothesis was that regulatory processes (both within and between episodes) would mediate the relationship between self-efficacy and adaptive performance. Lastly, they were also expected to mediate the relationship between role knowledge and skills, but more directly at the individual level and less prominently and more indirectly at the team level. This is because the impact of team knowledge and skill is dependent on collective action.

Participants were 78 teams (n=156) of undergraduates who were trained to operate a simulated attack helicopter during training. Each session had 3 phases, including role and team training (90 minutes), training evaluation session and a transfer of training session. After the training session, participants completed role-specific knowledge measures, and measures of self and collective efficacy and individual skill levels (Behavioral Anchored Rating Scale; BARS). They were then required to use the procedures and knowledge gained during training within a complex and novel situation requiring high interdependence between the roles of both team members (i.e., a pilot and a



gunner). In this case, the transfer task was designed to be of higher complexity and difficulty than the trained tasks, and required management of more information as well as a higher number of "discrete acts". This transfer task was designed to represent "a relatively weak form of the adaptation process" (p. 828), because it involved applying the same basic methods to a different exemplar. This research involved 3 different forms of adaptability, including handling emergencies or crises, managing work stress, dealing with unpredictable work situation (e.g., adjusting mission plans). The transfer mission began with the provision of 2 separate "intelligence reports" with complementary information and team members had 10 minutes to plan their attack and then to conduct their 15 minute mission, conducted in a more hostile and somewhat unfamiliar environment. After the transfer task, measures were taken of individual goal striving activities, team action processes, and individual and team adaptive performance. Team transition (e.g., mission analysis, planning) and team action processes (e.g., coordination, backup behaviour) were captured using behaviourally anchored rating scales (BARS).

Results showed that within-episode processes fully mediated the impact of transition processes on performance. However, given the pattern of results, it was necessary to revise the original model somewhat as shown in Figure 13.



Figure 13. Revised multilevel model of training and adaptive performance (Chen et al., 2005, p. 828)

At the team level, team knowledge impacted directly on the action processes that teams used, and these then impacted on team performance. Collective efficacy impacted on action processes both directly and indirectly (through transition processes), and team skill impacted only through collective efficacy. At the individual level, role knowledge, self-efficacy and individual skill were all correlated. Moreover, performance was directly influenced by knowledge of one's role as well as by individual skill. Self-efficacy showed the same effects as collective efficacy, impacting both directly and indirectly on goal striving activities.



Chen et al., 2005	
Methodology Used	2-person teams on a flight simulator task
Source/Cue/Training	Role and team training, training evaluation session
Probe/Test/Outcome	Transfer of training mission
Independent Variables	Role of either pilot or gunner
Dependent Measures	Performance of transfer mission – measures of individual goal choice activities, individual goal striving activities, team action processes, individual and adaptive performance Training evaluation measures – role-specific knowledge tests, collective efficacy measures
Findings	Post-training regulation processes were related to adaptive performance at both individual and team levels At the individual level, knowledge and skill influence adaptive performance, but only indirectly and weakly influence team adaptability. This relationship is mediated by collective efficacy and team regulation processes At the team level, efficacy beliefs had more relative importance to team adaptability than knowledge and skill

#### Table 12. Chen et al. (2005)

This research makes several contributions. First, it shows that the regulatory processes related to adaptive performance were similar at the individual and team levels. It also shows that knowledge, efficacy and skill are critical at both the team and individual levels, but have differing impacts. At both levels, efficacy beliefs and between-episode activities were related to adaptive performance only through within-episode or goal striving activities such as monitoring progress toward goals, system monitoring, team monitoring and backup behaviour and coordination

Based on these results, Chen et al. (2005) describe 2 primary differences in individual and team level models of transfer. First, while the Baldwin and Ford (1988) model argues that individual transfer performance is influenced by trainee factors, work factors and learning outcomes, the prominent Input–Process–Output (IPO) framework of team performance (Marks, Mathieu, & Zaccaro, 2001) argues that the relationship between team training and other inputs is mediated by team processes. The implication of this is that although the individual level model does not allow for post-training processes to impact on transfer (e.g., self-regulation), the IPO model does allow for this. Secondly, individual level models tend to consider a broader range of training outcomes (e.g., knowledge (cognitive), skills (behavioural) and affect) than team level models.

Given the importance of schema and mental model development within the broader transfer literature, understanding the factors that promote mental models within the team setting may elucidate team adaptation and transfer. Research by Marks, Zaccaro and Mathieu (2000) examined the link between communication and mental models and how this may impact the ability of an action team to adapt to novel situations. Action teams can be defined as teams that are proactive, both influencing and being influenced by their environment (e.g., emergency medical teams, nuclear power plant control teams, military teams). Specifically, this research focused on the role of communication and mental models on effective team performance. They also investigated the role of leadership briefings (typical control briefing vs. enhanced briefings intended to provide



additional situation awareness information to the team), team-interaction training, and situation-familiarity on team member's knowledge.

Marks and colleagues (2000) conducted a study using a 2 (leader briefing: enhanced vs. control) by 2 (team-interaction: training vs. control) by 3 (novelty of performance environment: one routine and two novel environments) mixed factorial design. Leader briefing and team-interaction training were evaluated as between-subjects independent variables while novelty of performance environment was assessed as a within-subjects variable. Undergraduates (n=237) were assembled into teams of three to participate in a war-game task. Teams played a computer based war-game where success was dependent on team members collaboratively developing strategies, coordinating actions, and completing tasks. All teams received a preliminary briefing via audiocassette by a 'remote leader' regarding mission goals before each performance task. Half of the participants received the control briefing, which included information about mission goals. The other half received an enriched briefing, which included information about mission goals as well as information regarding potential risks, opportunities in the battlefield, and prioritizing actions. The additional information provided to these participants equipped team members with information to improve their situation awareness (i.e., how to identify risks and how to respond; how to identify opportunities on the battlefield, and how to prioritize actions). In the control group, teams received basic training on how to play the game. Participants in the trained groups received basic training on how to play the game and additional instruction of how to effectively interact as a team. Both training sessions were administered via a 10 minute videotape. The novelty of the performance environment was manipulated for all participants. All teams first encountered a familiar environment (as seen in the practice trials), and then experienced two novel environments that were counterbalanced for order.

Participants first completed background questionnaires and a timed spatial orientation test. They were then randomly assigned to roles within teams. All team members received basic skills training and were provided with a checklist of team tasks that had to be completed successfully before advancing to the next phase of the experiment. Teams then were assigned to a team-interaction group (training or control) and received the leader brief (enhanced vs. control). Teams then were asked to individually complete a concept map prior to beginning a 20 minute team performance period of playing the war game. A cycle of leader brief, concept map completion, and measures of performance occurred three times. Marks and colleagues (2000) measured the team's shared mental models (both accuracy and similarity), communication, and performance. Shared mental models were assessed by evaluating the individually created concept maps that outlined team members' actions during the mission. Both similarity between maps and accuracy were measured. Team communication was also measured. Unlike other studies, Marks et al. measured the quality of the communication rather than the frequency. Each performance was audio taped and rated for assertiveness, decision making and mission analysis, adaptability and flexibility, situational awareness, leadership, and communication. Team performance was measured by assessing the number of enemies destroyed and rebuilt in friendly territory.

Results showed that team interaction training and enhanced leader briefs led to more similar and accurate mental models. Participants who did not receive team interaction training or the enhanced version of the leader briefing had significantly less accurate mental models than their counterparts. These mental models also positively influenced team communication and enhanced team performance. The positive benefits of good mental models and good communication were more pronounced in novel environments than in routine environments. These results suggest that training



and leader support that provided improved task knowledge and which encouraged shared mental models within teams had a positive impact on team's overall performance.<sup>6</sup> Shared mental models among a team may facilitate team adaptation as well as transfer of training. Similarly, team performance was more successful when teams showed shared mental models. Such teams also showed higher quality communication. Moreover, performance was found to be more successful in the routine environments than in novel environments. Thus, transfer of trained behaviour was seen to be more successful in dissimilar environments than in routine environments. Unfortunately, this research did not include a control condition that would allow comparison of transfer performance relative to a baseline condition.

Marks et al., 2000	
Methodology Used	Low fidelity tank simulation
Source/Cue/Training	Mission training briefing and training
Probe/Test/Outcome	Performance on war-game task (number of enemies destroyed and rebuilt)
Independent Variables	2 x 2 x 3 mixed factorial design - leader briefing (enhanced or short), training (basic or team interactive), novelty of performance environment (one routine and two novel environments)
Dependent Measures	Background, spatial orientation (time-test), concept map, performance, communication (assertiveness, decision making, mission analysis, adaptability, flexibility, situational awareness, leadership)
Findings	Teams with interactive training and enhanced leader briefs had more similar mental models (concept maps), better communication, and better communication than their counterparts.
	The impact of shared mental models and good communication were more pronounced in novel environments than in routine environments

Research by Entin, Weil, See, and Serfaty (2005) also explored team adaptation. This study examined the role of communication in adapting team structures to perform more effectively. This study examined whether low levels of congruence between team structure and task requirements (i.e., when team members' capabilities do not match the necessary task requirements) can result in performance decrements. The task performance exhibited by teams was used as an indicator of their levels of adaptation. According to Entin et al., characteristics of communication (e.g., measures of volume and frequency), are early indications of the effectiveness of efforts to change the team structure to relieve the incongruence. Monitoring communication patterns, they argue, provides insight to potentially emerging incongruence within a team and a team's ability to successfully adapt to novel situations. Presumably, shared mental models of the situation would diminish the need to communicate among team members as everyone's roles and responsibilities to fulfil a task would be understood (Wilson, Salas, Priest, & Andrews, 2007).

In Entin et al.'s (2005) study, five or six-person teams of naval post graduate attendees received team training on the Distributed Dynamic Decision-Making Simulator. Teams were trained together then divided into two conditions within either a functional organizational structure or a divisional organizational structure. All communications among team members were coded and

<sup>&</sup>lt;sup>6</sup> This study focuses on information provided by a leader, but beneficial information could also come from teammates.



grouped into one of the following categories: information request; action request; coordination request; information transfers; action transfers; action transfers using a specific resource; coordination transfers; and acknowledgements. Teams were presented with three joint force scenarios. Two scenarios were congruent with the team structure (functional or divisional) and one was incongruent with the team structure. Congruence was manipulated by matching (or mismatching) the requirements of the task with the asset capabilities managed by individuals within a given organizational structure. Congruent tasks were provided first. Prior to performing the incongruent tasks, teams were given feedback on their performance. They were then told that their structure would not be congruent with the upcoming missions and were provided descriptions of other teams' performance. Reading accounts of other teams' optimal and suboptimal performance associated with shifts in team structure was meant to encourage teams to change their own structure when they encountered similar challenges during less complex transfer. Measures of the teams' type, frequency and volume of communication during the task were taken.

Results of Entin et al.'s study (2005) showed that functional teams showed more overall communication than divisional teams. When heading into the incongruent situation, functional teams did not adapt very well, and initiated a greater volume of communication when experiencing more incongruence. Divisional teams by comparison showed less increase in communication in the incongruent situation because they adapted their structure more. Findings indicated that teams who cannot make structural adaptations when incongruence between task and structure emerges may struggle to complete the task. Within this study, this was evidenced by increased volume and frequency of communications. This study provides some evidence that communication (as an observable behaviour) is an indicator of incongruence between task requirements and team structure.

Entin et al., 2005	
Methodology Used	Scenario-based performance
Source/Cue/Training	Team training on the Distributed Dynamic Decision-Making Simulator
Probe/Test/Outcome	Three joint force scenarios
Independent Variables	Organizational structure (functional or divisional), joint force scenarios (functional or divisional or incongruent)
Dependent Measures	Task performance, communications (volume and frequency)
Findings	Functional teams showed more communication but did not adapt to incongruent situations as well as divisional teams Divisional teams showed more adaptation of their structure

Taken together, the studies detailed above provide empirical support that team and task knowledge improve mental models through communication, briefings, and increased situation awareness. Each study has shown that resulting team adaptation is improved. However, it remains unclear whether this adaptation actually resulted in better transfer, as this research did not include the necessary control condition.

Team adaptation has also been explored in research by LePine (2005). This research focused specifically on how teams continue to work effectively even when faced with unexpected challenges. LePine (2005) was interested in the impact of novel (or unexpected) situations when a team encounters tasks that cannot be managed using previously established procedures and routines. A more specific focus is on how team goals affect how teams manage unexpected



changes. When teams are working toward more difficult goals, this might make it harder to adapt their role structure unexpectedly. Their ability to adapt will be influenced by the levels of cognitive ability within the team, with more cognitive ability posited to facilitate higher levels of team adaptation. LePine (2005) describes two orientation perspectives that might influence the ability of teams to adapt in these situations, namely, <u>learning orientation</u> and <u>performance orientation</u>. According to LePine, learning orientation "reflects the desire to understand something novel or to increase competence in a task" (p. 1155). From this perspective, there is a tendency to view unforeseen changes as a challenge to overcome. Conversely, a performance orientation "reflects the desire to gain favourable judgements of performance or avoid negative judgements of competence" (Button, Mathieu, & Zajac, 1996; cited in LePine, p.1155). These two perspectives are also linked to adaptation. People with a learning orientation are likely to continue even as they face challenges, whereas people with a performance orientation may withdraw or avoid difficult situations. This will obviously make them less adaptable. These ideas were explored at the team level.

LePine (2005) conducted a study using 64 three-person teams (n = 192 participants) of college students. Participants were given interdependent roles where they had to assess threat levels of unidentified aircraft within a simulated environment. The software used for this task was Team Interactive Decision Exercise for Team Incorporating Distributed Expertise (TIDE2). Participants were assigned to play one of three roles. Each role required particular training to ensure participants could understand role-specific information sources, perform assessments, and make recommendations for team action (i.e., ignore, defend). Goal difficulty was manipulated by giving teams performance goals that were one standard deviation above and below mean performance levels. Training involved a number of practice trials, and then the experimental trials began. After 63 of the total 83 trials, gradual changes restricted communication between two members of the group. According to LePine, in order to foster realism, gradual as opposed to abrupt changes were implemented to see how uncertainty might be dealt with by the team.

Relevant measures included goal difficulty (rated using a 5-point sale), cognitive ability (Wonderlic Personal Test), goal orientation (Button, Mathieu, & Zajac's 1996 measure of goal orientation), and role structure adaptation. This dimension was scored in terms of how team members adapted to the breakdown of communication between the 2 members. As the unexpected event limited the ability of Bravo and Charlie to communicate, teams had to decide how to get the information to the required team member. The performance measure was the accuracy of threat assessments.

Results showed that members' goal orientation did not impact significantly on the likelihood of role structure adaptation. Teams comprised of members with higher cognitive ability adapted to change more effectively. Team goal orientation was shown to be a moderator of the relationship between goal difficulty and team adaptation (as indicated by adapting communication strategies when required). A Hierarchical Generalized Linear Model (HGLM) analysis showed that adaptive team behaviour was determined by both team goal difficulty and team members' goal orientation collectively when team members had a learning orientation. Teams with members who had low-learning orientation were three times less likely to adapt to the changed situation when the goal difficulty was high. However, the opposite pattern was evident for teams with varying levels of performance orientation, but that learning orientation interacts with goal difficulty to facilitate adaptation, while performance orientation combines with goal difficulty to hinder adaptation.

Findings from supplementary analyses showed that teams are more likely to adapt to unexpected changes in the situation when teams demonstrate positive tones in communication and focus on



problem-solving and planning rather than monitoring progress in performance. Utilization of problem-solving and planning activities (in lieu of observing performance) may facilitate team adaptation.

As a whole, then, this study suggests that the ability of team members to adapt to unforeseen situations by transferring previously attained skills is influenced by their cognitive abilities, in combination with the difficulty of the active goal and their goal orientation. Training should reinforce the importance of behaviours that support interpersonal and transition processes during times of rapid change as elements that may be beneficial to team adaptation. Training should also encourage positive communications, and focus on strategic and task objectives may be beneficial to team adaptation.

Lepine, 2005	
Methodology Used	Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise
Source/Cue/Training	Simulations exercise identifying threats
Probe/Test/Outcome	Exercise involving collecting and sharing threat information
Independent Variables	Pre-existing: Cognitive abilities of team members Goal orientation (learning or performance orientation) Manipulated: Goal difficulty (high standard or low standard relative to practice trials)
Dependent Measures	Performance (accuracy of identifying threats) Role structure adaptation
Findings	Cognitive ability promotes adaptation Goal difficulty interacts with team learning goal orientation to promote adaptation Goal difficulty interacts with team performance goal orientation to hinder adaptation

Table 15.Lepine et al. (2005)

Generalizations from this study may be limited by the setting and the type of task. It may also be argued that predictors and outcomes were not explicitly examined within a complete, inclusive model. There may be additional processes that contribute to orientation that were not considered within this study and may effect team adaptation differently. This study showed that the difficulty of team goals, and members' goal orientation predict interpersonal, transition, and action processes, all of which predicted team adaptation.

Within the team literature, although there is a somewhat higher level of fidelity (relative to the analogical research), most of the contexts in which team adaptation and transfer have been studied have remained fairly artificial. Being able to exert adequate levels of experimental control, however, may limit the level of fidelity that can be achieved to some extent.

## 5.3 Team Training Interventions

In recent years, there has been increasing focus on actual interventions intended to promote higher levels of transfer and/or team adaptability (Baldwin, Ford and Blume, 2009). In a recent metaanalysis, Salas, DiazGranados, Klein, Burke, Stagl, Goodwin, and Halpin (2008) explored the efficacy of the most common interventions employed for team training. These are cross-training,



team coordination and adaptation training, and guided team self-correction training. Relevant research on the efficacy of these interventions is described in the section that follows.

Cross-training is a strategy of training team members involving rotation of their roles during training in order to promote knowledge about the roles of other team members and task expertise. Team members are trained in the tasks, roles, and responsibilities of fellow team members in order to promote a common understanding of each other's roles and how they are interrelated, and how the entire team functions as a whole (Burke, Salas, Cannon-Bowers, & Spector 1992, cited in Volpe, Cannon-Bowers, Salas, 1996). Cross-training helps to develop what Volpe and colleagues call "interpositional knowledge" (IPK). IPK is said to establish common understanding of roles and responsibilities within the team, and develop the framework of shared mental models. Equipped through cross-training, members may more accurately predict and anticipate each other's needs and actions (Volpe et al.). IPK reflects team and task expertise by developing knowledge that instructs members on who should do what and when by developing shared knowledge structures.

Cross-training seeks to develop team members' skills in order that they may, recognize, anticipate, and undertake complimentary, supplementary, or reinforcing behaviours. Team members are then better prepared to provide backup behaviour by understanding when teammates may become overburdened and step in to assist when required (Salas, DiazGranados, Klein, Burke, Stagl, and Halpin, 2008), and also to step into learned roles and responsibilities when called upon. Cross-training teaches each member practical skills of a role that they may be expected to perform when certain circumstances arise (e.g., a colleague is absent). Cross-training helps develop team members' task knowledge, team knowledge, and mental models regarding the team's functional capability. As such, this construct seems closely related to the concept of team adaptation, as team members with shared knowledge structures.

Volpe and colleagues (1996) conducted a study looking at cross-training. They were interested in the factors that foster effective team performance. Supported by previous research, they suggest that effective team coordination is likely to be positively related to the amount of IPK each member of the team possesses. Their research sought to identify training methods that promote transfer. To investigate this, they focused on instructional strategies impact effective team performance.

This study used a controlled laboratory setting, and participants were trained individually prior to being paired into a two person team. Two-person teams were required to fly an aircraft and shoot down enemy aircraft in a computer-based simulation. Training was manipulated by providing different levels of instruction (presumably leading to differential levels of interpositional knowledge to team members. A 2 x 2 factorial between-subjects design compared training methods (cross-training vs. no training) and workload (low vs. high). The task was structured to make roles interdependent, requiring team collaboration and communication for a successful mission. Participants in the cross-training condition received information about the system controls (e.g., joystick and keyboard operation), and team roles and responsibilities (their own and those of teammates). Those in the control condition received similar training, except they learned only those roles and responsibilities relevant to their position. Each participant was trained to proficiency on their own task, while those in the cross-training condition were also trained to proficiency on all roles within the team. Prior to beginning the task, participants in the high workload condition were provided a short five minute instruction on the appropriate information-reporting procedure. High workload was induced by having participants conduct additional information-seeking behaviour and respond to inquiries from the 'base' above their normal responsibilities.

The dependent variables were teamwork processes, communication, and task performance. Volpe and colleagues hypothesized that teams with cross-training would perform better under high



workload because they would exhibit better teamwork behaviour (exhibited by technical coordination, team spirit, interpersonal cooperation, and cross monitoring), communicate more appropriately (exhibited by pushing information to one another as required, agreeing more with each other, and providing less task-irrelevant information).

Overall performance was measured by the duration or frequency of particular incidences. For example, an offensive task was evaluated based on the time it took to shoot down the first enemy target, frequency with which teams had the enemy in range, frequency with which teams had their radar locked on the enemy, and the total number of enemy aircraft destroyed. Similarly, a defensive task was evaluated by the number of times the enemy locked its radar on the team aircraft). Teamwork was measured using a modified version of the Teamwork Rating Scale (TRS), and communication was measured based on the quality (e.g., relevant vs. irrelevant communications) and patterns specific to aircrew communications (e.g., categories such as requesting information, volunteering information, indicating agreement).

Volpe et al. (1996) found that cross-training supported positive task performance. Specifically, teams that had received cross-training required less time to destroy the first enemy aircraft, had higher team competency, and higher overall team quality ratings than did teams that did not receive cross-training. All offensive tasks were completed better by teams in the cross-training condition. Teams that received cross-training also exhibited significantly higher teamwork ratings. In terms of communication, teams that received cross-training did volunteer significantly more information however, they did not exhibit other anticipated behaviours (e.g., acknowledge teammates more often, agree with teammates more often, request less information). In fact, teams within the cross-training conditioned were noted to provide more task-irrelevant information; opposite from what was hypothesised.

These results provide support that cross-training positively influence members' abilities to anticipate and predict information needs of their teammates, and this may be because the team members had more developed mental models compared to those participants who only learned about their role and responsibilities for task fulfilment. Indeed, research has shown that teams with members who possess more similar and accurate mental models perform better relative to those with more dissimilar and inaccurate mental models (Cooke et al., 2003; Burke et al., 2006; Mark et al, 2000; Mondoux et al., 2004; LePine, 2005). The interaction between training condition and workload, on the other hand, were not as expected. Volpe et al. found that workload significantly degraded teamwork and communication. However, it did not negatively impact task performance measures.


Volpe et al., 1996	
Methodology Used	Role training on computer flight task
Source/Cue/Training	Training about the system controls and roles and responsibilities (their own and/or those of teammates)
Probe/Test/Outcome	Coordinated flight activities tasks
Independent Variables	2 (training methods - cross-training or no training) x 2 (workload - low or high) factorial between-subjects design
Dependent Measures	Offensive task performance (time to shoot target, frequency enemy was in range, frequency enemy was locked, and number of enemies destroyed) Defensive task performance (frequency enemy locked),
	Teamwork (Teamwork Rating Scale)
	Communication (quality and patterns)
Findings	Teams that received cross-training were better at offensive tasks and teamwork, but communicated more irrelevant information than their untrained counterparts

#### Table 16. Volpe et al. (1996)

Volpe et al.'s (1996) study suggests that establishing role task proficiency as well as those for team members can help people anticipate and predict information needs of others. Theoretically, cross-training may provide the basis for teams to more effectively coordinate and exchange information based on shared mental model development. For Burke and colleagues (2006), providing team members with knowledge that develop team and task expertise (i.e., IPK) may be the key factor that improves team adaptation to novel situations. Cross-training was demonstrated as one method through which this knowledge can be developed. Unfortunately, any conclusion about the role of mental models seems tenuous in this research, given that mental models were not specifically measured.

Cooke, Kiekel, Salas, Stout, Bowers and Cannon-Bowers (2003) further investigated the use of cross-training and IPK to improve team performance. Building on the work of Volpe and colleagues (1996), Cooke et al. compared a conceptual, abbreviated form of cross-training and full cross-training such as that used by Volpe and colleagues. Cooke and colleagues designed a cross-training technique called conceptual cross-training (CCT) that attempted to develop shared knowledge regarding team members' roles, responsibilities and interdependence. Conceptual information was provided including task analysis diagrams with designated responsibilities of all team positions (pilot, navigation officer, or intelligence officer), and a diagram of information shared between team members. This study manipulated the degree to which cross-training practically or conceptually provided IPK.

A full cross-training methodology (FCT) focused on training members to proficiency in the tasks of each team member. Using these two methods, four conditions were compared: full cross-training (FCT) (25 minute training in each of the three positions), short conceptual cross-training of 35 minutes (CCT-35), long conceptual cross-training of 75 min (CCT-75) identical to the CCT-35 though more time was provided for review of the material, and a control group (no cross-training). All training involved practice opportunities and short proficiency tests (e.g., demonstrate flight procedures) and role knowledge tests (e.g., 10 multiple choice questions) prior to the mission. Feedback of incorrect answers was provided and an opportunity to seek out the correct answer was given.



Participants were asked to complete two helicopter rescue-and-relief missions in teams of three. Each person was given one of three roles: pilot, navigation officer, or intelligence officer. The roles were interdependent as personnel in each role would have relevant information required to successfully accomplish the mission. Tasks within this mission included route planning under constraints (e.g., poor weather, hostile situation), compiling information and agreement on route plan, and plan execution (sometimes requiring rerouting and alternate planning). The planning portions required more systematic processes and team decision-making whereas the execution phase required extensive team coordination and shared situation awareness within a dynamic environment. The majority of the information required to complete the full mission was distributed among individual team members.

Cooke et al. (2003) measured team performance and team knowledge. Team performance was measured by the rate of mission tasks successfully completed (proportion of mission tasks completed divided by the allotted time used). Team knowledge was measured at two intervals, namely after the training prior to the first mission, and after the second mission. Evaluation criteria included long-term taskwork and teamwork knowledge. Taskwork knowledge was evaluated using a self-report rating. Overall accuracy, accuracy of own roles and others' roles, accuracy of IPK, and intrateam similarity were analyzed. Teamwork knowledge was gathered through a self-report questionnaire on the type of information (e.g., weather, planned route, hostile area) exchanged between each team member. This information was also scored (based on a key devised by the experimenter) for overall accuracy, accuracy of own roles and other's roles, accuracy of IPK, and intrateam similarity.

As expected, results showed that teams with greater taskwork and teamwork knowledge had higher task completion rates (Cooke et al., 2003). Higher task work IPK correlated positively with team performance. However, the same was not found for teamwork IPK. Contrary to expectations, the CCT training conditions did not produce better performance. Results showed that better performance slightly favoured the FCT condition. In addition, participants in the FCT condition seemed to provide more taskwork knowledge and IPK. Those in the FCT condition also had higher teamwork knowledge in overall accuracy and IPK accuracy. According to Cooke et al., results suggest that teamwork and taskwork knowledge requires experience to develop and methods attempting to override that process may not be as effective as complete, direct training. A focus on acquiring accurate taskwork knowledge at early stages is supported by this study as FCT focused primarily on this learning, while CCT focused primarily on teamwork. It seems that team performance can be best predicted by positional taskwork knowledge and intrateam similarity of task work knowledge. Specifically, team performance is optimized when members possess "accurate knowledge of their own roles and are dissimilar to each other in the structure of this knowledge" (p. 195). Thus, rather than 'shared knowledge' arising out of similarity and overlap, the authors conclude that shared knowledge is best understood as a product of high positional accuracy in combination with clearly divided responsibility among team members' roles,



Cooke et al., 2003	
Methodology Used	Cross training
Source/Cue/Training	Full or conceptual cross-training on team roles
Probe/Test/Outcome	Two helicopter rescue-and-relief missions
Independent Variables	Training (Full cross-training, short conceptual cross-training, long conceptual cross- training, or no cross-training)
Dependent Measures	Team performance (rate of mission tasks successfully completed) Team knowledge (overall accuracy, accuracy of own roles and others' roles, accuracy of IPK, and intrateam similarity)
Findings	Full cross training resulted in better performance rather than conceptual training. Teams with greater task work and teamwork knowledge had higher task completion rates

#### Table 17.Cooke et al. (2003)

The studies above provide some evidence that cross-training is one methodology that can at minimum influence less complex forms of transfer, perhaps by promoting IPK and shared mental models. Moreover, cross-training should help teams adapt to changing circumstances as it provides them with shared knowledge of team tasks, team member's roles and responsibilities, and role interdependencies. Members are equipped with knowledge to enhance team processes, team outcomes, and shared cognition ultimately improving team adaptation. However, more specific research needs to be conducted to show how cross-training can contribute to transfer of training. In other words, does the development of shared mental models through training provide the requisite knowledge structures for team members to transfer training to novel situations?

<u>Team coordination and adaptation training (TCAT)</u><sup>7</sup> focuses on developing shared mental models through providing teams with the opportunity to work together. Teachings within this instructional approach target skills such as recognizing potential stress related changes that may produce problematic or challenging behaviours (physical and psychological) and situations; determining adaptive coordination strategies; and identifying compatible strategies according to the situation (Entin & Serfaty, 1999). The goal of this training is to enable teams to better coordinate and communicate in high stress situations and to adapt their actions as necessary.

Good performance under stressful conditions is attributed to changes made to team processes and team outcomes. Emphasis is placed on effective team coordination and the team's shared mental models. Moreover, within training, practice opportunities are given prior to evaluation. In this study, teams are provided two different transfer opportunities, one considered to be part of the training, and one representing the transfer target task. Entin and Serfaty (1999) propose training that helps to establish strong mental models and processes that help teams maintain and update accurate shared mental models will be most effective in maintaining team performance. TCAT is one method which trains team members to improve both mental models and coordination. According to Entin and Serfaty (1999), this training may be one of the few that directly addresses the process of transfer.

<sup>&</sup>lt;sup>7</sup> Formerly referred to as crew resource management (CRM).



Participants were 30 naval officers performing anti-air warfare (AAW) simulation tasks in teams of five. The main objectives were to identify and assess air and surface contacts as friend or foe. Each team member had a role constructing a combat information centre (CIC). One experienced officer was tasked to be the tactical action officer (TAO), while the other four members arranged themselves to four positions, identification supervisor (IDS), tactical information coordinator (TIC), anti-air warfare coordinator (AAWC), and electronic warfare supervisor (EWS). Each of the four positions was set up at a different watch station where participants gathered information necessary to draw conclusions about the contacts.

The manipulations in this study were training (TACT vs. TACT + vs. no training), workload induced stress (high vs. low), and test condition (pre training vs. post training). The TCAT condition provided teams with information in three phases. Phase 1 covered identification of signs and symptoms of stress and high workloads. In Phase 2, teams learned five adaptive coping strategies to use in high stress situations which included "preplanning, use of idle periods, favouring information transmission over action/task coordination, anticipation of information needs (implicit communication, and dynamic redistribution of workload among team members" (Entin & Sefaty, 1999, p. 316). Phase 3 was administered as a practice session in which teams were provided the opportunity to practice what they had learned in two practice scenarios. Baseline data was gathered during these practice missions prior to training. A second TCAT condition, TCAT +, provided the same training plus instructions for the leader to provide regular SITREPS. The final condition was a control group. These teams were given training that asked them to look globally at how their performance impacted other platforms within the battle group.

Entin and Serfaty (1999) took measures of team performance, communication and coordination, and workload. Team performance was evaluated by four observers trained on the Team AAW (anti-air warfare) Performance Scale that looked at overall performance as well as teamwork (including dimensions such as team orientation, communication behaviour, monitoring behaviour, feedback behaviour, and backup behaviour). Two psychologists were commissioned to code all team behaviours. From this analysis, communication and coordination were assessed for the type and content (e.g., request information, request action and task, transfer information, transfer action and task, acknowledgements). Workload was evaluated using the TLX, a self-report measure developed by Hart and Staveland (1988), after the task was completed.

Results supported Entin and Serfaty's (1999) hypothesis that performance in high stress conditions can modify mental models and improve outcomes through adaptive team training on coordination, communication, and cooperation. The TCAT and TCAT + training did impact team performance, coordination, and communication. Teams in both conditions performed better on the transfer task demonstrating improvements in team AAW performance (pre-training mean = 4.13, post-training mean = 4.90; t (9) = 2.44, p < .05) and requested less information than those teams in the control condition. Teams in the training conditions were better able to anticipate their colleagues' needs and provided them with concise information. Entin and Serfaty proposed that teams may have used more implicit communication because they relied on their shared mental models more when workload was high.

In conclusion, Entin and Serfaty (1999) argue that developing and maintaining mental models facilitates performance high workload situations and improves team adaptation. Moreover, they argue that these gains cannot be accomplished by either cross-training or IPK training approaches. While cross-training improves knowledge of member's roles, responsibilities, and may foster intermember workload awareness, they argue that it does not support robust team strategies used in team adaptation. Looking back to the team adaptation model proposed by Burke et al. (2006), it



may be that cross-training affects individual characteristics, while TCAT seeks to influence emergent states.

Entin & Serfaty, 1999	
Methodology Used	Team coordination and adaptation training
Source/Cue/Training	Training for signs and symptoms of stress, adaptive coping strategies, practice scenarios, and SITREPS
Probe/Test/Outcome	Anti-air warfare (AAW) simulation tasks
Independent Variables	Training (TCAT or TCAT + or no training), workload induced stress (high or low), and test condition (pre training or post training)
Dependent Measures	Observed team performance (Team AAW Performance Scale) Communication and coordination (type and content) Workload (TLX)
Findings	Training resulted in better team performance, coordination, and teams with training requested less information than teams without training

 Table 18. Entin and Serfaty (1999)

A recent meta-analysis (Salas, DiazGranados, Klein, Burke, Stagl, Goodwin, and Halpin, 2008) investigated the impact of team training interventions on team performance. This was meant to clarify the nature of training by "establish[ing] boundary conditions of team training for enhancing team outcomes, and impart valuable information for organizational stakeholders in charge of designing, delivering and evaluating team training interventions" (p. 804). The interventions explored were cross-training, team coordination and adaptation training and guided team self-correction training. This meta-analysis looked at 7 studies meeting strict criteria (e.g., full reporting necessary for extraction of statistical tests, case studies, not using non-performance outcome indicators etc.). These studies had a total of k = 28 hypothesis tests and 695 team members in 178 teams.

This meta-analysis showed that the team training interventions explored within the meta-analysis had a small to moderate positive impact on team performance (z fisher = 0.293, r = .286), and this was not influenced by whether the measure was an objective performance measure or supervisory ratings of performance.

In terms of the efficacy of different types of interventions, cross-training did not significantly improve team performance. However, team self-correction training did improve performance significantly (z fisher = 1.851, r = .448) but this effect was small. The strongest and most influential team training intervention was team adaptability and coordination training (z fisher =1.72, r = .607). However, the authors noted that these interventions were not always entirely separate within the studies reviewed, and this could have obscured their true impact. To address this concern, they attempted to quantify the unique contribution of each of these interventions, and to arrive at an estimate of the unique contribution of each type (after partialling out the contributions of other interventions). These analyses showed that cross-training did not contribute to team performance, but that guided team correction did contribute positively to team performance when considered as an independent factor. Team coordination and adaptation training made a marginal contribution to team performance. This pattern of results led the authors to conclude that team adaptation training is the most potent form of training for improving team performance. They



argue that there is no evidence of the efficacy of cross-training, but some limited evidence that team correction training can help to improve performance.

Training can be focused on taskwork on or teamwork. Taskwork interventions are intended to heighten knowledge, skills, and/or attitudinal competencies. Teamwork interventions focus on improving collaboration and cooperation within a team. Some interventions target both taskwork and teamwork. From their meta-analysis, Salas et al. noted that there was insufficient evidence to conclude which of the team training types (taskwork, teamwork, or a combination of taskwork and teamwork) most improved cognitive and affective indicators (e.g., socialization, trust, confidence in team members abilities), team process indicators (e.g., communication, coordination, strategy development), or performance outcomes (e.g., task success) in teams. They argue that there is some evidence that teamwork and a mixed content training may be more effective to improve process outcomes, though further investigation of this is required.

#### 5.4 Discussion

This chapter attempted to explore a possible link between transfer of training from a team perspective and the concept of team adaptation. This required considering the concept of team adaptation, team research relevant to adaptability and/or transfer, and team training interventions.

As noted, there are multiple definitions of team adaptation available in the literature. The definition of adaptation as "a metamorphic shift in the team network in the short term to deal with the performance demands of a nonroutine task" (Kozlowski et al., 1999, cited in Burke et al., 2006) seems to capture the most critical aspects of adaptation. According to one of the most prominent models of team adaptation (Burke et al., 2006), transfer of training represents a change in team performance as the result of a salient cue that leads to some sort of response. Team adaptation could result in new structures or the modification of existing structures, abilities, and/or behaviours or cognitions directed at specific goals. These definitions describe adaptation as occurring in response to a novel or nonroutine task, and as involving some sort of substantive shift within the team system. The need to perform a new or atypical task is at the heart of many transfer challenges. According to Burke and colleagues, teams are able to overcome obstacles by forming or manipulating existing structures within a task (such as a cognitive schema or inter-member communication). This functional outcome of team adaptation is a realignment of performance which improves how the team operates and/or achieves objectives. Team adaptation is argued to be improved by developing and improving both individual and team mental models, shared situation awareness, positive transfer environment and team culture, and motivation.

There is some limited evidence of conceptual models relevant to team adaptation and transfer. Burke and colleagues (2006) designed a comprehensive model of team adaptation that describes an adaptive 3 phase cycle, and considers emergent states, individual characteristics, and job design characteristics. Building on this model, studies including factors found to be prominent within the literature were reviewed. Specifically, team expertise, task expertise, leader support, and orientation (attitude) are argued to significantly influence team performance. However, from the perspective of understanding transfer within teams, working to identify the factors that impact on the adaptability/transfer process may be premature if the exact nature of transfer is not well-defined and understood. This suggests that considerable effort will be necessary to attempt to bridge this gap within the team literature.

Although available research focuses on the factors purported to influence team adaptation and transfer, there is unfortunately relatively little empirical research that systematically works to understand the process of transfer within a team environment. One study explored analogical



reasoning within teams, but showed no positive effects of working in teams (Lowenstein et al., 2009). However, it is unclear whether the experimental task provided enough complexity to engage team processes fully. Unfortunately, the link between the ability of teams to adapt in new environments and their ability to transfer their skills and knowledge is not sufficiently explored in the available research.

This chapter also explored several relevant team training interventions that are intended to promote team adaptability and/or transfer. Given the importance of team members being able to realign themselves to other team members, cross-training has aimed to help team members understand the roles and responsibilities of other members in order to better anticipate their needs. Similarly, team coordination and adaptation training has aimed to promote shared mental models in order to aid communication and coordination. This form of training is shown in research by Entin and Serfaty (1999) to have improved performance on a transfer task. Moreover, research comparing the efficacy of several team training interventions showed cross-training having little impact, but team adaptability and coordination training having a strong impact and team self-correction training having a smaller (but still significant) impact on team performance. However, considerable research is also necessary within this literature to show the power of these interventions to influence team transfer performance in novel environments.

The team transfer and adaptation literature is relatively underdeveloped, and seems focused more on the various factors that might influence transfer rather than on how transfer occurs. Although there is considerable team research exploring the impact of particular factors (e.g., training, team structure) on team performance, transfer has often been measured indirectly rather than directly. The assumption within the team adaptation literature seems to be that if teams have learned the core skills that they require, they will be able to generalize these skills once they encounter a new or expected situation. Unfortunately, this assumption that transfer will occur has not been adequately tested in the available literature. Indeed, the link between team adaptation and actual transfer is relatively unelaborated. It is also unclear how the gap between the cognitive processes that need to occur at the individual level might extend to the team level, and there is no coherent body of research that seems to directly address this important issue.

The concluding chapter addresses the important conceptual linkages between team adaptation and transfer in more detail.



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# 6. Conclusion

The purpose of this literature review was to explore the literature relevant to transfer (within the psychological domain) and to team adaptation (within the team domain), with a view to understand the potential linkage between these constructs. This effort is meant to inform efforts to understand collaborative performance and learning and how these can be enhanced.

As noted earlier in this report, theoretical distinctions working to more clearly identify the contextual influences on transfer (e.g., knowledge, modality) and to distinguish open and closed skills (e.g., Barnett and Ceci, 2002) represent important progressions in theory that will helpfully aid the systematic progression of transfer research. Baldwin et al. (2009, p. 44) argue that the "…increase in diverse samples and authentic skills is a positive trend that has the potential to increase the generalizability of training transfer findings." However, there is still considerable progress required to better understand transfer.

This review shows some conceptual linkages between research in the cognitive domain and the team adaptation domain. In both the cognitive and team literature, comparison is a key aspect of the underlying process. Both surface and structural similarities are argued to drive the comparison process, and promote the ability to generalize from one situation to another. The process of analogical reasoning relies on comparisons that allow people to see the commonalities between the source task or object and the target task or object. For example, the seminal analogical study by Gick and Holyoak (1983) shows the importance of comparing multiple analogs to better schema development and transfer. Within the analogical reasoning literature, comparison processes are very constrained, involving subtle differences between stimuli and between situations. Comparison processes are also indicated as a key aspect of team adaptation. A particularly important form of comparison within a team context is comparison of one's own roles and responsibilities with of other teammates. For example, the Burke et al. (2006) model of team adaptation emphasizes the role of comparison in developing a common view of the task among team members (resulting in increased ability to generalize). Comparison processes also seem to be at the core of many relevant forms of team training (e.g., cross training). As such, within both domains, implicit or explicit comparison processes are argued to underlie transfer and the ability to generalize from one situation to another.

The role of schemas and/or mental models to promoting transfer is also common to both domains. The analogical reasoning literature describes comparison as important because it helps to promote the formation of schemas that can then help facilitate transfer when moving to a novel environment (e.g., Gick and Holyoak, 1983). Research exploring analogical reasoning purports to show the potential value of mental models in promoting transfer from one situation to another (Day and Goldstone, 2011). This research argues that mental models arising from principle-based reasoning can promote the ability to transfer this knowledge from one challenge to a very different one by relying on a similar strategy.<sup>8</sup> Mental models formed during the comparison process are also argued to promote better performance within the team domain. This is evident in the Burke et al. (2006) model of team adaptation, which emphasizes shared mental models as an important emergent state related to team adaptation. Research by Marks et al. (2000) shows the impact of

<sup>&</sup>lt;sup>8</sup> As noted earlier, however, more conclusive evidence that mental models influenced the transfer of knowledge would be helpful for interpreting the findings of this research.



interactive training, and argues that better shared mental models within a team can promote better performance in new and unexpected environments. The emergence of formed schemas or mental models is one way in which this commonality can be instantiated to assist the transfer process. Within both domains, then, the strategies learned and/or knowledge gained through comparison processes are argued to promote the emergence of a more unified body of knowledge (i.e., a mental model). This model is argued to facilitate the transfer of skills or knowledge when moving to a new situation. This suggests that working to understand the impact of mental models on transfer is a particularly important area of future research.

Within both domains, the concept of "learning-to-encode" is also relevant. In analogical reasoning research, one of the ways that comparison can influence transfer is that it changes how people process information when encountering a future example relevant to a previously encoded example. Research within the team domain also notes the importance of similar processes related to team learning. Specifically, Edmonson (1999; cited in Burke at al., 2006) describe team learning as a gradual process of testing and evaluating assumptions and beliefs to better calibrate strategies to new situations. As such, the process of learning how to encode information is relevant within both areas.

In both the cognitive and team domain, moreover, comparison is argued to assist transfer partly because it promotes selective attention to some features of an element while limiting focus on extraneous elements. A key assumption in the analogical transfer literature is that comparison of two objects is particularly likely to assist transfer when it emphasizes relational structure rather than on idiosyncratic or surface features. This is the assumption underlying the concept of relational schema abstraction advanced by Gentner, Loewenstein, Thompson and Forbus (2009). Team adaptation is also described as requiring comparison to help strip away the non-common characteristics to see important commonalities more clearly (e.g., Burke et al., 2006). Similarly, team training interventions such as cross-training are also predicated on team members using comparison to better understand the roles of their teammates. It seems likely that an important part of this process is selectively noting the concepts underlying the process of transfer are somewhat similar within the cognitive domain and the team domain.

However, the research reviewed in this report illustrates the lack of specificity about the exact nature of transfer. The literature reviewed in this report shows some efforts to understand the nature of transfer and the influences on it. However, studies that show any change in performance as the result of training or instruction have sometimes been labelled as evidence of transfer having occurred. This suggests that transfer will need to be more strictly defined and measured more rigorously.

A lack of focus and strong methodology has made it difficult to reconcile the discrepant and inconsistent findings in the available research. At the empirical level, research shows a range of possible influences on positive transfer within a range of diverse literatures. Although there are some fairly consistent influences identified in recent research and meta-analyses (e.g., the role of self-efficacy, cognitive ability) within the transfer of training domain, many more possible factors (e.g., social support) show somewhat mixed and inconclusive results. Because many of these factors are very context-dependent, it is difficult to find clear patterns in the midst of a range of diverse findings. Hence, it is also not currently possible to identify the most crucial influences on transfer, whether a product of training, the work environment, or of the individual. With so many possible variables, and with a somewhat inconsistent definition of transfer in play, it is difficult to draw strong conclusions about the nature of transfer and its influences. Baldwin et al. (2009) note



one of the biggest lacks in the literature is knowing how to best promote training objectives, saying "...we find it curious that such information is still conspicuously absent in the reporting of most transfer studies. It is difficult to contemplate a cumulative body of evidence that would provide practical guidance to learning professional without further classification and taxonomic work on just what is being trained and what objectives are desired." (Baldwin et al., 2009, p. 44). This suggests that working to dimensionalize the many possible influences on transfer in play may be helpful.

Some researchers seem to argue that attending to variables that have received less attention to date may be important. For example, Baldwin et al. (2009, p. 57) suggest "....more careful attention to variables that have been either ignored or controlled. Rather than generating additional ways to exclude these variables/questions from study, our research needs to explicitly explore how these variables may interact with training design to facilitate or inhibit transfer outcomes." This argument from transfer of training researchers seems to highlight a core difference in approaches to understanding transfer within the cognitive domain and the transfer of training domain. While researchers within the transfer of training domain have introduced a full range of possible influences on transfer, they seem to have given less interest to the process of transfer itself. Indeed, the relative success showing transfer in the analogical reasoning literature seems to suggest that using stricter methodologies with fewer factors in play may help to elucidate transfer.

A prominent challenge in understanding transfer is the lack of complexity in measurement in some research. Blume et al. (2010) point out the inherent measurement problems within much of the transfer of training research. They conclude that "...it is impossible to draw strong conclusions about transfer relationships from studies...(text removed).... because we cannot disentangle the true relationship from the measurement issues." (Blume et al., 2010, p. 1094). To remedy this, they indicate that the strongest laboratory studies must not use single-source independent and transfer variables at the same time (e.g., from the participant). They also argue that when measuring and researching transfer of training (Blume et al., 2010), it will be critical to use measures that tap both the use of trained skills and which measure the effective use of these trained skills. Ideally, they argue, these measures should come from multiple sources rather than just a single source (e.g., supervisors and peers) and should explore transfer at multiple points in time (rather than just immediately after training). Measures should also be constructed in accordance with the nature and objective of training (e.g., open skill or closed skill) as well as being tailored to the training context. More careful measurement will hopefully help to better capture team transfer and adaptability in its full dimension.

Despite the lack of clarity in the research literature, it is also clear that trainers and researchers will still need to make the best of the information that is available about transfer. Blume et al. (2010, p. 1096) argue that "...the roughly equivalent predictive power of several individual and situational predictors reflects the reality that there are no magic bullets for leveraging transfer. This means that training professionals should consider multiple transfer strategies in combination." From a pragmatic perspective, this means that researchers working to understand transfer and trainers will need to consider the nuances of the transfer process, the design of training, the complex environment within which training occurs, and characteristics of the individual that are likely to influence transfer.

Although much of the existing research could be labelled at best as representing fairly constrained forms of transfer, the most critical challenges that teams face will require understanding more complex forms of transfer. Once the transfer process can be reliably captured by researchers in this domain, investigations will need to extend to higher levels of fidelity.



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### References

Aguinis, H. & Kraiger, K. (2009). Benefits of training and development for individuals and teams, organizations, and society. Annual Review of Psychology, 451-474.

Ansburg, P. I., & Shields, L. (2003). Training overcomes reasoning schema effects and promotes transfer. Psychological Record, 53(2), 231-242.

Baldwin, T. T., & Ford, J. K. (1988). Transfer of training: A review and directions for future research. Personnel Psychology, 41, 63-105.

Baldwin, T. T., Ford, J. K., & Blume. B. (2009). Transfer of training 1988-2008: An updated review and agenda for future research. International Review of Industrial and Organizational Psychology, In G. Hodgkinson and J. Ford (Eds.), Volume 24. New York: Wiley.

Bandura, A. & Locke, E. (2003). Negative self-efficacy and goal effects revisited. Journal of Applied Psychology, 88, 87-99.

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. Psychological Bulletin, 128(4), 612–637.

Beard, R. L., Salas, E., & Prince, C. (1995). Enhancing transfer of training: Using role-play to foster teamwork in the cockpit. International Journal of Aviation Psychology, 5(2), 131-143.

Bell, B., & Kozlowski, S. (2008) Active learning: Effects of core training design elements on self-regulatory processes, learning, and adaptability. Journal of Applied Psychology, 93(2), 296-316.

Blanchette, I., & Dunbar, K. (2000). How analogies are generated: The roles of structural and superficial similarity. Memory and Cognition, 28, 108-124.

Blume, B., Ford, K., Baldwin, T. & Huang, J. (2010). Transfer of training: A meta-analytic review. Journal of Management, 36, 1065-1105.

Bransford, J. D., & Schwartz, D. L. (1999). Rethinking Transfer (Vol. 24). Washington, DC.

Burke, C. S., Stagl, K. C., Salas, E., Pierce, L., & Kendall, D. (2006). Understanding team adaptation: A conceptual analysis and model. Journal of Applied Psychology, 91(6), 1189-1207.

Catrambone, R. (2002). The effects of surface and structural feature matches on the access of story analogs. Journal of Experimental Psychology: Learning, Memory, and Cognition, 28(2), 318-334.

Chen, Z., Yanowitz, K. L., & Daehler, M. W. (1995). Constraints on accessing abstract source information: Instantiation of principles facilitates children's analogical transfer. Journal of Educational Psychology, 87(3), 445-454.

Chen, G., Thomas, B. & Wallace, J. (2005). A multilevel examination of the relationships among training outcomes, mediating regulatory processes, and adaptive performance. Journal of Applied Psychology, 90(5), 827-841.

Cheng, E. W. L., & Hampson, I. (2008). Transfer of training: A review and new insights. International Journal of Management Reviews, 10, 327-341.

Cheng, E. W. L., & Ho, D. C. K. (1998). Transfer of training: Some practical thoughts from theoretical studies. International Journal of Management, 15(1), 14-19.



Colquitt, J. A., LePine, J. A., & Noe, R. A. (2000). Toward an integrative theory of training motivation: A meta-analytic path analysis of 20 years of research. Journal of Applied Psychology, 85(5), 678-707.

Cooke, N. J., Kiekel, P. A., Salas, E., Stout, R., Bowers, C., & Cannon-Bowers, J. (2003). Measuring team knowledge: A window to the cognitive underpinnings of team performance. Group Dynamics: Theory, Research, and Practice, 7(3), 179-199.

Day, S., Goldstone, R. (2011). Analogical transfer from a simulated physical system. Journal of Experimental Psychology: Learning, Memory and Cognition, 37, 551-567.

De Corte, E. (2003). Transfer as the productive use of acquired knowledge, skills, and motivations. Current Directions in Psychological Science, 12, 142-146.

De Croock, M. B. M., & Van Merriënboer, J. J. G. (2007). Paradoxical effects of information presentation formats and contextual interference on transfer of a complex cognitive skill. Computers in Human Behavior, 23(4), 1740-1761.

Engle, R. A. (2006). Framing interactions to foster generative learning: A situative explanation of transfer in a community of learners classroom. The Journal of the Learning Sciences, 15(4), 451–498.

Entin, E. E., & Serfaty. D. (1999). Adaptive team coordination. Human Factors: The Journal of the Human Factors and Ergonomics Society, 41, 312-325.

Entin, E. E., Weil, S. A., See, K. A., & Serfaty, D. (2005). Understanding team adaptation via team communication. Paper presented at the In the Proceedings of the Human Systems Integration Conference, Washington, DC.

Ford, J. K., Smith, E. M., Weissbein, D. A., Gully, S. M., & Salas, E. (1998). Relationships of goal orientation, metacognitive activity, and practice strategies with learning outcomes and transfer. Journal of Applied Psychology, 83(2), 218-233.

Gentner, D., Ratterman, M.J., & Forbus, K. (1993). The roles of similarity in transfer: Separating retrievability from inferential soundness. Cognitive Psychology, 25, 524-575.

Gentner, D., Loewenstein, J., Thompson, L. & Forbus, K. (2009). Reviving inert knowledge: Analogical abstraction supports relational retrieval of past events. Cognitive Science, 33, 1343-1382.

Gentner, D., Loewenstein, J., & Thompson, L. (2003). Learning and transfer: A general role for analogical encoding. Journal of Educational Psychology, 95(2), 393-408.

Gick, M. L., & Holyoak, K. L. (1980). Analogical problem-solving. Cognitive Psychology, 12, 306-355.

Gick, M. L., & Holyoak, K. L. (1983). Schema induction and analogical transfer. Cognitive Psychology, 15, 1-38.

Greeno, J. G. (2006). Authoritative, accountable positioning and connected, general knowing: Progressive themes in understanding transfer. Journal of the Learning Sciences, 15, 537-547.

Goettl, B. & Shute, V. (1996). Analysis of part-task training using the backward-transfer technique. Journal of Experimental Psychology: Applied, 3, 227-249.



Holladay, C. L., & Quiñones, M. A. (2003). Practice variability and transfer of training: The role of self-efficacy generality. Journal of Applied Psychology, 88(6), 1094-1103.

Holton, E. (2005). Holton's evaluation model: New evidence and construct elaborations. Advances in Developing Human Resources. 7(1), 37-54.

Johnson, M. D., Hollenbeck, J. R., Ilgen, D. R., Jundt, D., Derue, D. S., & Barnes, C. (2006). Team adaptation to structural misalignment: Determinants of alternative change mechanisms. Paper presented at the In the Proceedings of Command and Control Research and Technology Symposium, San Diego, CA.

Jones, P.E. & Roelofsma, P. H. (2000). The potential for social contextual and group biases in team decision-making: biases, conditions and psychological mechanisms. Ergonomics, 43, 1129-1152.

Kozlowski, S., Toney, R., Mullins, M., Weissbein, D., Brown, K. & Bell, B. (2001). Developing adaptability: A theory for the design of integrated-embedded training systems. In E. Salas (Ed.), Advances in human performance and cognitive engineering research (Vol. 1, pp. 59-123). Amsterdam: JAI/Elsevier Science.

Krueger, G. P., & Banderet, L. E. (2007). Implications for studying team cognition and team performance in network-centric warfare paradigms. Aviation, Space, and Environmental Medicine, 78(5), B58-B62.

Kurtz, K. J., & Loewenstein, J. (2007). Converging on a new role for analogy in problem-solving and retrieval: When two problems are better than one. Memory & Cognition, 35, 334-341.

LePine, J. A. (2003). Team adaptation and postchange performance: Effects of team composition in terms of members' cognitive ability and personality. Journal of Applied Psychology, 88, 27-39.

LePine, J. A. (2005). Adaptation of teams in response to unforeseen change: Effects of goal difficulty and team composition in terms of cognitive ability and goal orientation. Journal of Applied Psychology, 90, 1153-1167.

Lim, J., Reiser, R. A., & Olina, Z. (2009). The effects of part-task and whole-task instructional approaches on acquisition and transfer of a complex cognitive skill. Educational Technology Research & Development, Springer Science & Business Media B.V., 57, 61-77.

Lobato, J. (2006). Alternative perspectives on the transfer of learning: History, issues, and challenges for future Research. Journal of the Learning Sciences, 15(4), 431-449.

Lobato, J. (2008). Research methods for alternative approaches to transfer: Implications for design experiments. NJ: Erlbaum.

Lobato, J., & Siebert, D. (2002). Quantitative reasoning in a reconceived view of transfer. Journal of Mathematical Behavior, 21, 87–116.

Lobato, J., Burns Ellis, A., & Muñoz, R. (2003). How "focusing phenomena" in the instructional environment support individual students' generalizations. Mathematical Thinking and Learning, 5(1), 1–36.

Loewenstein, J., Thompson, L., & Gentner, D. (2003). Analogical learning in negotiation teams: Comparing cases promotes learning and transfer. Academy of Management Learning and Education, 2(2), 119-127.

Loewenstein, J., Thompson, L., & Gentner, D. (1999). Analogical encoding facilitates knowledge transfer in negotiation. Psychonomic Bulletin & Review, 6(4), 586-597.



Marks, M. A., Zaccaro, S. J., & Mathieu, J. E. (2000). Performance implications of leader briefings and team-interaction training for team adaptation to novel environments. Journal of Applied Psychology, 85, 971-986.

Marton, F. (2006). Sameness and difference in transfer. Journal of the Learning Sciences, 15, 499-535.

Mondoux, J., Auderset, P. & Dillenbourg, P. (2004). Abstraction and transfer in collaborative learning. Swiss Federal Institute of Technology Lausanne.

Moran, S., Bereby-Meyer, Y., & Bazerman, M. (2008). Stretching the effectiveness of analogical training in negotiations: Teaching diverse principles for creating value. Negotiation and Conflict Management Research, 1(2), 99-134.

Salas, E., DiazGranados, D., Klein, C., Burke, C. S., Stagl, K. C., & Halpin, S. M. (2009). Does team training improve team performance? A meta-analysis. Human Factors, 50(6), 903–933.

Salas, E., Nichols, D. R., & Driskell, J. E. (2007). Testing three team training strategies in intact teams: A meta-analysis. Small Group Research, 38(4), 471-488.

Schwartz, D., & Bransford, J. (1998). A time for telling. Cognition and Instruction, 16(4), 475-522.

Schwartz, D., & Martin, T. (2004). Inventing to Prepare for Future Learning: The hidden efficiency of encouraging original student production in statistic instruction. Cognition and Instruction, 22(2), 129-184.

Sternberg, R. J. (2000). Handbook of Intelligence. Cambridge University Press, United Kingdom.

Tracy, J., Tannenbaum, S., & Kavanagh, M. (1995). Applying trained skills on the job: The importance of the work environment. Journal of Applied Psychology, 80(2), 239-252.

Thompson, L., Gentner, D., & Loewenstein, J. (2000). Avoiding missed opportunities in managerial life: Analogical training more powerful than individual case training. Organizational Behavior and Human Decision Processes, 82(1), 60-75.

Thorndike, E. L., & Woodworth, R. S. (1901). The influence of improvement in one mental function upon the efficiency of other functions. Psychological Review, 3, 247-261.

Volpe, C. E., Cannon-Bowers, J. A., Salas, E., & Spector, P. E. (1996). The impact of cross-training on team functioning: an empirical investigation. Human Factors, 38(1), 87-100.

Wilson, K. A., Salas, E., Priest, H. A., & Andrews, D. (2007). Errors in the heat of battle: Taking a closer look at shared cognition breakdowns through teamwork. Human Factors, 49(2), 243-256.

Yamnill, S., & McLean, G. N. (2001). Theories supporting transfer of training. Human Resource Development Quarterly, 12(2), 195-208.

Yelon, S. and Ford, J. (1999). Pursuing a multidimensional view of transfer. Performance Improvement Quarterly, 12(3), 58-78.



# Annex A - Models Relevant to Transfer of Training

Transfer has perhaps most frequently been explored in terms of how to best facilitate the effectiveness of training efforts. This chapter explores the best known model related to transfer of training by Baldwin and Ford (1988), and two lesser known but relevant models. This chapter describes three models, including Baldwin and Ford's (1988) Transfer Process Model, Holton's (2005) Learning Transfer System Inventory, and Colquitt, LePine and Noe's (2000) Integrative Theory of Training Motivation.

As shown in early sections of this report, many research efforts have explored how transfer occurs and in general how this is accomplished. This large body of existing research, however, has resulted in the emergence of different perspectives on the very nature of transfer. Perhaps not surprisingly, some research efforts that explore transfer from a different point of view have recently emerged, along with a limited number of research efforts. In the sections that follow, we discuss the theoretical underpinnings for these perspectives and, when possible, include related research investigating transfer.

#### Transfer of Training - Baldwin & Ford (1988)

Baldwin and Ford explore a comprehensive set of factors that facilitate transfer within workplace environments. Following a comprehensive review of the previous transfer literature (primarily literature relevant to the workplace), Baldwin and Ford (1988) developed a model of the transfer process. This model appears to be the most frequently cited model of training transfer, and is in Figure 14.



#### Figure 14. A model of the transfer process (Baldwin & Ford, 1988, p. 65)

They classified the factors affecting the transfer of training into three main categories, including training inputs, training outputs, and the conditions of transfer.

Training-input factors emerge from three sources including:



- trainee characteristics, consisting of personality, skill, ability, and motivational aspects;
- training design factors, pertaining to the incorporation of established learning principles, the sequencing of training materials, and the degree to which the training content is relevant to the job; and
- the work environment, which considers organizational variables such as the level of supervisory and peer support as well as restrictions or opportunities to act upon learned behaviours in the workplace.

Baldwin and Ford (1988, p. 64) describe training outputs as "the amount of original learning that occurs during the training program and the retention of that material after the program is completed". These learning outputs culminate in the conditions of transfer. The conditions of transfer refer to generalization and maintenance of the learned material over a period of time in the workplace, and are meant to reflect actual transfer.

As Baldwin and Ford's model specifies, training inputs and training outputs are assumed to have both direct and indirect effects on the conditions of transfer. They identify six linkages to describe these effects. Beginning with Linkage 6, learning and retention are argued to have a direct effect on generalization and maintenance. In order for new knowledge and/or skills to transfer to the workplace, training material must be learned as well as retained (Kirkpatrick, 1967, cited in Baldwin & Ford, 1988). The model further predicts that both trainee characteristics and the work environment will have direct effects on generalization and maintenance, apart from initial learning and retention of training materials (Linkages 4 & 5). Finally, trainee characteristics, training design, and the work environment are thought to directly influence training outputs (Linkages 1, 2, & 3), and through it indirectly influence transfer of training.

This model has been the most influential model of transfer within real-world environments (e.g., the workplace).

#### The Learning Transfer System Inventory (Holton, 2005)

Holton (1996, 2005) developed a comprehensive framework of transfer as part of a larger evaluation framework aimed at understanding and diagnosing causal influences at play in human resources development interventions. As noted by Yamnill and Mclean (2001), the "traditional" approach to conceptualizing transfer of training is to envision a horizontal link between training and performance (e.g., Baldwin & Ford, 1988). That is, various training inputs lead to learning and retention, which lead to generalization and maintenance of training material. However, most training and development programs are primarily undertaken for the purposes of increasing individual, team, and organizational performance levels. To address these outcomes and provide a means of assessing the training-performance link, Holton (1996, 2005) presented a conceptual evaluation model of training called the Learning Transfer System Inventory (LTSI). The LTSI was designed to take into account "all factors in the person, training, and organization that influence transfer of learning to job performance" (Holton, 2005, p. 44). Accordingly, the LTSI framework incorporates 16 factors believed to have an influence on the transfer of training. These are detailed in Table 19.



Factors	Definition
Learner readiness	Extent to which individuals are prepared to enter and participate in training
Motivation to transfer	Direction, intensity, and persistence of effort toward using skills and knowledge learned in a work setting
Positive personal outcomes	Degree to which applying training on the job leads to outcomes that are positive for the individual
Negative personal outcomes	Extent to which individuals believe that not applying skills and knowledge learned in training will lead to negative personal outcomes
Personal capacity for transfer	Extent to which individuals have the time, energy, and mental space in their work lives to make changes required to transfer learning to the job
Peer support	Extent to which peers reinforce and support use of learning on the job
Supervisor support	Extent to which supervisors/managers support and reinforce use of training on the job
Supervisor sanctions	Extent to which individuals perceive negative responses from supervisors/managers when applying skills learned in training
Perceived content validity	Extent to which trainees judge training content to accurately reflect job requirements
Transfer design	Degree to which (a) training has been designed and delivered to give trainees the ability to transfer learning to the job, and (b) training instructions match job requirements
Opportunity to use	Extent to which trainees are provided with or obtain resources and tasks on the job enabling them to use training on the job
Transfer effort performance expectations	Expectation that effort devoted to transferring learning will lead to changes in job performance
Performance-outcome expectations	Expectation that changes in job performance will lead to valued outcomes
Resistance/openness to change	Extent to which prevailing group norms are perceived by individuals to resist or discourage the use of skills and knowledge acquired in training
Performance self-efficacy	An individual's general belief that they are able to change their performance when they want to
Performance coaching	Formal and informal indicators from an organization about an individual's job performance

Table 19. Learning	<b>Transfer System</b>	<b>Inventory (LTSI)</b>	(Holton, 2	2005, p. 45-6)
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For Holton (2005), training effectiveness is measured by three outcome variables: learning (i.e., achieving the outcomes desired from a training intervention); individual performance (i.e., changes in individual performance arising from applying training to the job); and organizational performance (i.e., individual performance positively impacting organizational level results). A



conceptual map shows how the 16 factors relate to the three outcome measures of the LTSI, as shown in Figure 15.



Figure 15. LTSI conceptual map of constructs (Holton, 2005, p. 48)

According to Holton (2005), the LTSI has been well supported to date, showing evidence of construct, criterion, and cross-cultural validity. Three of the four factor groupings included in the LTSI model are similar to the training inputs suggested by Baldwin and Ford's (1988) model (trainee characteristics, training design, and work characteristics). Holton's model builds on Baldwin and Ford's conceptualization, by including the "secondary influences" of performance self-efficacy and learner readiness, and by increasing the number of variables used to measure the common factor groups. By doing so, the LTSI seems to provide a more complete account of influential factors. Although Holton's LTSI is theoretically similar in many ways to Baldwin and Ford's model, it may offer some advantages. By conceptually nesting the factors affecting transfer into a framework which ties learning outcomes to performance measures, the model may provide a means of understanding, measuring, and perhaps facilitating transfer in applied contexts.

# Integrative Theory of Training Motivation (Colquitt, LePine, & Noe, 2000)

Research by Colquitt, LePine, and Noe (2000) indirectly looked at transfer as an outcome of training, with specific emphasis on the role of training motivation. This research reviewed 25 years (i.e., 1975-2000) of literature on training motivation. Training motivation is defined as "the direction, intensity, and persistence of learning-directed behaviour in training contexts" (p. 678). On the basis of the extant research, these authors formed two competing models attempting to describe the role of motivation-to-learn in the transfer of training to job performance. As a first step, Colquitt et al. (2000) identified a number of variables that had frequently been linked to training effectiveness in previous studies examining training motivation and learning outcomes. Variables included antecedents to training motivation (e.g., individual characteristics, situational



characteristics, job variables), and outcomes (e.g., declarative knowledge, skill acquisition, transfer, job performance), as well as other related variables, such as cognitive ability.

Colquitt et al. (2000) then constructed models representing two plausible ways in which the key variables might relate to motivation to learn. In the first, effects of distal variables, such as one's age and personality, are predicted to impact on motivation to learn only through variables more proximal to the training session, such as one's pre-training self-efficacy and valence. The second model (depicted in Figure 16) offers a partially mediated alternative; extending the fully mediated model, this portrayal adds pathways to represent direct influences of distal variables on one's motivation to learn.



#### Figure 16. Integrative theory of training motivation (Colquitt et al., 2000, p. 684)

Using meta-analytic techniques, the researchers tested the relationships predicted by the models, and through meta-analytic path analysis, compared which model performed best in predicting motivation to learn. Results showed that the partially mediated model explained a larger proportion of the variance in motivation to learn (73%) in comparison to the fully mediated model, which explained only 46%. These results suggested that the partially mediated integrative model of



training motivation may be a more accurate representation of the motivation-to-learn construct than the full model.

Although the focus of Colquitt et al.'s (2000) meta-analysis was the "motivation to learn" construct, this research is useful to the study of transfer. Transfer was indirectly examined as a dependent variable as part of the path analysis. Therefore, the variables which acted upon transfer can be individually observed. For instance, the analysis indicated that the four learning outcomes (declarative knowledge, skill acquisition, post-training self-efficacy, reactions) explained about half of the variance in transfer. However, when more distal variables (personality, age, situational variables) were included, a total of 81% of the variance in transfer could be explained. These results support the assertion that individual characteristics along with relevant situational variables do have a direct impact on the transfer of training in the workplace, even over and above what is taken away from the training session (as measured by the learning outcomes). A more detailed account of Colquitt et al.'s results indicate that relative to individuals with similar learning outcomes, a person with a higher external locus of control, a high level of organizational commitment, career planning, manager support, and/or who works in a positive climate should show higher rate of transfer following a training session.

Overall, Colquitt and colleagues (2000) present an integrated model of learning motivation. This model is consistent with many factors identified in other models of transfer (e.g., Baldwin & Ford, 1988; Holton, 2005). These include trainee characteristics, the work environment, and a wide range of transfer outputs (e.g., declarative knowledge and reactions, and job performance). Further, the authors point to some practical implications of their findings for the needs-assessment phase of a training programme. An important implication is that more attention should be paid to the 'distal' factors encompassing a persons' individuality and situational circumstances. They suggest that trainers would benefit from leveraging these factors at the outset of training.

#### Alternative Perspectives on Transfer

The relatively low rate of demonstrable evidence for transfer has spurned a number of alternative perspectives. In the following chapter, we examine some of the core research studies pertaining to transfer of training from multiple perspectives in an effort to reveal its nature as well as to highlight the different paradigms for studying it. It should be pointed out that despite the varied perspectives what they all seem to have in common is the desire to understand the generalizing activity of students/trainees to new situations, following some kind of learning situation. Revealing the process involved in the generalizing activity may, therefore, help to uncover the nature of transfer.

**Preparation for Future Learning** – Other researchers believe that the dominant approach to transfer to date, which they call direct application theory, is responsible for the elusiveness of complex transfer (Bransford & Schwartz, 1999; De Corte, 2003; Lobato, 2006). Proponents of direct application theory typically use a sequestered problem-solving approach to exploring transfer and constrain transfer to when people are able to directly apply previously learned material to a new situation or problem. This approach ultimately prevents participants from "seeking help from other resources such as texts or colleagues or by trying things out, receiving feedback and getting opportunities to revise" in order to prevent "contamination" from extraneous information (Bransford & Schwartz, 1999, p. 68). This approach often provides participants with some initial learning followed by some kind of application of the learned material on a transfer target task (e.g., problem-solving) with little time in between tasks (e.g., minutes, hours, a week). The transfer studies reviewed previously in this report have adopted this methodological approach.



In contrast, Bransford and Schwartz argue that constraining the concept of transfer to the direct application/sequestered problem-solving perspectives "neglects the active, productive, interactive, and contextualized nature of learning" (de Corte, 2003) and they propose broadening current conceptualizations of transfer. Rather than viewing transfer in terms of simply applying previously learned knowledge and skills to a given situation, transfer should be conceived as an active and constructive process in which people modify their environments and utilize the resources available (Bransford & Schwartz). More specifically, they argue that a comprehensive conceptualization of transfer needs to consider "how people learn in knowledge-rich environments" (p. 68), and that a "preparation for future learning" (PFL) perspective may be helpful. From a constructionist perspective, people learn by building on previous knowledge, but using sequestered problemsolving methodological design may hinder the expression of people's natural abilities. For example, examining unconstrained problem-solving transfer requires researchers to extend their focus and to see whether people have actually gained the ability to solve new problems rather than simply focusing on their ability to solve a constrained transfer target problem. This would require consideration of extended learning rather than "one-shot task performances" (Bransford and Schwartz, 1999). Similarly, Marton (2006) emphasizes the importance of repeated opportunities for shaping knowledge. He explains, "rather than focusing on relations between two isolated situations, we should focus on relations between sets of situations that have certain relevant aspects in common" (Marton, 2006, p. 503). Moreover, knowledge also needs to be understood as being produced rather than reproduced. Bransford and Schwartz (1999) also hold that when people learn new skills and knowledge, part of this learning experience includes developing the ability to structure environments in a way that promotes the use of the available resources at one's disposal (such as texts, mentors, etc.). According to this perspective, knowledge gained in a novel setting exists to the extent that it is enacted or constituted when it is actually used (Lave, 1988, cited in Marton, 2006). As Marton (2006) points out, discerning the link between two instantiations of the same principle only occurs when people address the second instantiation (situation B). Knowledge gained in situation A is constituted in situation B. Moreover, both differences and similarities within the initial learning situation (situation A) and the transfer situation (situation B) help make the general principle salient (Marton, 2006) and therefore useful.

Viewing transfer as contextualized and actor-oriented, the regularities between the transfer source and the transfer target reflect a personal structuring of the situation in relation to current goals and prior knowledge (Lobato, 2006). Transfer does not simply mean aligning previously learned knowledge to a new task (e.g., as in the case of Gick and Holyoak's experiments investigating analogical transfer). Active control of learners underscores the importance of agency in conceptualizing the nature of transfer, and not simply aligning expert learning for expert performance.

In addition to the focus on agency, the <u>context</u> in which learning occurs is also important according to Bransford and Schwartz (1999). They claim that the PFL perspective diminishes the tendency to use old behaviour in a new situation, a situation that requires the introduction of new concepts and procedures to fulfil tasks. In their words, "educational environments that are designed from a PFL perspective emphasize the importance of encouraging attitudes and habits of mind that prepare people to resist making old responses by simply assimilating new information to their existing concepts or schemas" (Bransford & Schwartz, 1999, p. 81). For example, having opportunities and experience collaborating or seeking multiple viewpoints might help prevent overreliance on the tendency to assimilate new knowledge into existing knowledge systems when situations actually demand adaptive or innovative problem-solving to accomplish tasks effectively. Bransford and Schwartz cite research that shows transfer sometimes involves conceptual change rather than the



maintenance of previously held behaviours and beliefs. In fact, some of the research examined for this review seems to support this position, as incorporating or adopting diverse strategies have been shown to facilitate transfer outcomes (e.g., Moran et al., 2008). Moreover, transfer seems to improve when participants can utilize resources at their disposal (e.g., others) to gather further information rather than simply solving problems independently.

Methodologically, the PFL perspective suggests that longitudinal approaches may be a better predictor of transfer of knowledge and skills than one-shot approaches (as used in sequestered problem-solving) because trainees may have the opportunity to more fully realize procedures, principles or theories that increase transfer within a novel situation (Mayer, 1999, cited in Lobato, 2006). Moreover, with a one-time measure, learning activities and experiences that promote but which may require more time may go unobserved (Bransford and Schwartz, 1999). Lobato (2006), in fact, suggests that ethnographic methods may be more effective than experimental research methods for improved exploring effective performance and transfer.

A few studies have been shown to support the PFL theory of transfer. For example, Schwartz and Bransford (1998) explored the extent to which there are moments in "knowledge development that are indicative of a 'time for telling' or a 'readiness' for being told something" (Schwartz & Bransford, 1998, p. 476). One way to stimulate a 'readiness' moment is by helping the learner activate relevant prior knowledge ahead of 'being told something' (e.g. ahead of reading text or listening to a lecture). They argue that when learners are prepared in this way, their comprehension and memory of the presented material is enhanced (e.g. Beck, 1984, cited in Schwartz & Bransford, 1998). This is the case, in part, because the extracted information is handled more efficiently, and it is likely to hold greater meaning if it can be mapped into the learners' existing knowledge. This perspective, then, may be less applicable to novice learners who lack an existing relevant informational base (Schwartz & Bransford).

Schwartz and Bransford (1998) conjecture that one way to overcome a shortage of previous knowledge is by "creating a time for telling by doing more telling" (Schwartz & Bransford, 1998, p.477) or, by providing learners the required background information. However, the practicality of this method may be limited because most texts and lectures assume some level of differentiated knowledge beyond what is accessible to novices. Learners, as a result, may falsely presume that they comprehend the information, although they might also have only superficial understanding because they may have missed some important distinctions that would be obvious only to an expert (Schwartz & Bransford, 1998).

Schwartz and Bransford (1998) hypothesized that rather than simply presenting the learner with background information in the form of text or a lecture (known as the transmission model of disseminating information), a better strategy for creating a well-differentiated knowledge base is to provide an opportunity for learners to actively analyze sets of contrasting cases, while encouraging them to be sensitive to information that they might otherwise miss (e.g. Glick & Patterson, 1992, as cited in Schwartz & Bransford, 1998). According to Schwartz and Bransford (1998, p. 479), presenting contrasting cases has been shown to "help people to notice specific features and dimensions that make cases distinctive", and form the "bases for guiding other activities such as creating images, elaborating, generating questions and learning". Once a more differentiated base is formed, the learner is said to be prepared for future learning.

This hypothesis was tested across three experiments, in which groups of students participated in different experiences and were then assessed on how well they learned from a subsequent lecture or text. In the first experiment, undergraduate students took part in a within-subject experiment



exploring whether prior analysis of contrasting cases prepared students for a lecture on cognitive psychology better than if they had read text summaries of the same cases. Participants were asked to analyze a set of contrasting cases covering a group of target constructs. They were also provided with read-only text summaries of cases representing different target constructs. Five days later, the students attended a lecture that presented material covering both groups of target constructs. One week later, the students' level of understanding was assessed.

Two outcome measures captured participants' level of comprehension. A verification test assessed understanding at a superficial level (i.e., notice of distinctive features was not necessary). This required answering 8 true-false questions covering the target concepts. Participants were also required to perform a prediction task, which assessed deep, expert-like understanding of targeted concepts and gauged their ability to predict the outcome of a proposed hypothetical experiment. Performance was evaluated by coding for the use of target constructs in the students' proposed outcomes. Results showed that students' performance on the verification test was near ceiling levels (93% average accuracy), illustrating that students understood all of the target concepts at least at a superficial level. The prediction test, on the other hand, showed a different pattern of results. Prediction task results showed that when asked to analyze contrasting cases, students' proposed outcomes tended to include more of the target constructs learned, suggesting that "students could not perform effectively unless they had analyzed the cases" (Schwartz & Bransford, 1998, p. 491).

This raised the question of why analyzing cases helped students on the prediction task when simply reading about cases did not. In a follow-on study, Schwartz and Bransford investigated two competing explanations: knowledge assembly (i.e., learning occurs as a result of effort and attention to assemble ideas with meaningful connections) and discovery as discernment (i.e., learning occurs when individuals have generatively discerned features and structures that differentiate relevant aspects of the world). Graduate students in an introductory cognitive psychology course were randomly divided into two groups. In the first group, they were instructed to actively summarize a text (two short book chapters) or to simply read the same text after analyzing the contrasting cases. Both methods covered the target constructs. Learning was assessed one week later using the prediction test described in Experiment 1.

Results showed that analyzing contrasting cases led to better prediction of outcomes than simply summarizing the chapter. Moreover, time spent on the task did not differ between the two conditions. Taken together, this supported Schwartz and Bransford's (1998) belief that underlying the effectiveness of the contrasting cases method is a learning process, characterized by the generation of discernable features that differentiate relevant aspects of the world. However, it remained unclear whether simply discovering distinctions would be sufficient for deep understanding. That is, without an overriding framework to help individuals develop a theory to explain these distinctions, would analyzing cases alone set the stage for future learning?

Schwartz and Bransford's (1998) third experiment attempted to simultaneously pull together all of the study's hypotheses. It examined whether analysis of contrasting cases without a follow-up lecture led to strong performance on the prediction test. Participants included 36 college sophomores with no prior courses relevant to the target concepts. Students were divided into three treatment conditions. The first condition (labelled telling + telling) had students summarize a relevant chapter before attending a lecture covering the target constructs. This tested the hypothesis that "creating a time for telling by doing more telling" may not be optimal. A second condition (discovery + discovery), had students analyze the same set of contrasting cases twice (no lecture). This tested the hypothesis that "analyzing these cases alone is not sufficient for deep learning" (p.



500). And lastly, a discovery + telling condition, in which students analyzed contrasting cases and then attended a lecture, tested the hypothesis "that analyzing the contrasting cases prepares the student to learn by being told" (p. 500).

Results on the prediction test (i.e., the total number of predictions presented) showed that neither the double-telling nor the double-discovery condition were sufficient for deep understanding compared to the discovery + telling condition. In fact, the percentage of predictions suggested by the discovery + telling group (43.8%) was greater than the other conditions combined (31.1%). Schwartz and Bransford concluded that this "suggests a synergy between the opportunity to differentiate one's knowledge of the phenomenon at hand and the opportunity to hear a conceptual framework that articulates the significance of those phenomena" ((Schwartz & Bransford, 1998, p. 503). It appears that teaching by telling can broaden one's understanding provided one has gained sufficient knowledge in advance. In their study, this was accomplished by reviewing contrasting cases. Schwartz and Bransford concluded that "analyzing the contrasting cases provided students with the differentiated knowledge structures necessary to understand a subsequent explanation at a deep level" (Schwartz & Bransford, 1998, p. 504).

Schwartz & Bransford, 1998	
Methodology Used	Analysis of contrasting cases
Source/Cue/Training	Learned about selected cognitive psychology constructs
Probe/Test/Outcome	Asked to generate predictions regarding the outcomes of a hypothetical experiment involving cognitive psychology constructs
Independent Variables	Sequence of and type of training provided: summarize text & attend lecture, vs. analyze contrasting cases (twice), vs. analyze contrasting cases & attend lecture;
Dependent Measures	Learning verification test ( 8 true-false questions) Prediction task: predict outcomes of a hypothetical experiment (i.e., number, quality of predictions)
Findings	Analyzing the contrasting cases creates differentiated knowledge structures necessary to understand a subsequent explanation at a deep level

Table 20. Schwartz and Bransford (1998)

**Transfer as Actor Oriented** - Other researchers argue that agency is fundamental to the success of transfer of training. For example, Greeno (2006) argues that crediting people with authorship, with generating ideas and developing topics acknowledges the role of individuals in a learning context. For Greeno, adaptive and innovative activity that characterizes productive transfer requires an agent who is both an author of and accountable for action. Such positioning, he holds, includes "being entitled and expected to move about the environment freely, with access to resources throughout the environment and with the authority to use, adapt, and combine those resources in unconventional ways" (p. 543). According to Greeno, transfer emerges from "participating in an activity in one situation influences one's ability to participate in another activity in a different situation" (Lobato, 2008). This emphasis on agency and the way in which an agent interacts with things and people presents a different conceptualization of transfer.

According to Lobato, classic transfer approaches typically focus on the context and structure of tasks without properly considering the participants' purposes and construction of meaning in the transfer situation itself. The primary distinction between the classic approach to transfer and the actor-oriented approach is "the effort to relinquish normative notions of what counts as transfer"



(Lobato, 2008, p. 174). This can be accomplished, Lobato argues, by looking at the specifics of the instructional experiences, immersing oneself in the world of the trainee, and revealing how these influence one's perception of the new situation (Lobato, 2008). Both correct and incorrect performances, therefore, become relevant because, unlike negative transfer, construed as interference, incorrect performances are considered an important building block in learning and as such become subsumed into the construction of similarity across situations (Lobato, 2008).

In the initial learning situation of classic transfer studies methodology, participants are taught a solution, response or principle before being asked to perform or transfer the acquired knowledge to a second situation (i.e., transfer target) that shares some structural similarities with the first situation. Comparisons are made to one group who received the initial learning to another group who did not receive any instruction. The difference between the two groups represents the measure of transfer, either negative transfer in the event that the trained group does worse than the untrained group (the transfer source interferes with transfer) or positive transfer in the event that the former performs better than the latter. To demonstrate actual knowledge acquisition and production, viewing transfer from the actor-oriented perspective demands a different approach and subject of investigation. Citing diSessa and Wagner (2005), Lobato (2008) argues that transfer studies should not simply consider "successful or unsuccessful performance", but rather "describe knowledge" by looking at the influence of previous activities on a current one and examining how individuals identify similarities between situations, which could be unexpected or nonstandard.

Lobato (2008) adopts an ethnographic methodological approach. This method, she argues, helps identify similarities that participants develop between the transfer and learning situations, by answering questions like "What are the images by which learners construct two situations as similar?" or "How does the environment structure the production of similarity?". The design of the actor-oriented transfer study, she explains, includes semi-structured interviews both before and after the experiment. Like classic transfer studies, tasks are generated that share structural features, but differ with respect to their surface details. The transfer tasks are then used as "settings" to investigate the unique ways in which participants connect learning and transfer situations. Conceiving transfer as an instance of knowledge production rather than knowledge application requires considering how the participant modifies, changes, adapts and learns in the transfer situation. Finally, rather than assuming that the transfer task shares similar surface feature complexities as the learning tasks, Lobato includes in post-interviews questions pertaining to the participants' conceptualization of the transfer situations.

For Lobato (2008), transfer occurs if the following four claims can be substantiated. These include:(1) changes in the participants' conceptualization of and performance on the transfer target from pre- to post-interviews; (2) participants' have limited knowledge of relevant material entering the experiment as reflected in performance in a pre-interview task and early curriculum activities; (3) identifying plausible relationships of similarity between the student's reasoning on the transfer tasks in the post-interview and in some activity during the design experiment; and (4) the participants' reasoning on the transfer task is not entirely spontaneous. According to Lobato, this represents the role of agency in the generalization of learning.

Lobato then connects the individual level of generalizing activity to the social level. Referred to as "focusing phenomena" (Lobato, Ellis, & Munoz, 2003), she considers transfer to include the role that instructors, mathematical language, curriculum material, and relevant artefacts play, as students search and attend to particular features in their learning environments over others. "Rather than studying the occurrence of transfer as a function of controlling external conditions", she argues, "the construct of focusing phenomena affords the study of transfer as a constrained,



socially situated phenomenon" (Lobato, 2008, p.182). To understand the sociocultural influence of the learning environment, Lobato employs "collective units of analysis" to locate practices and norms particular to the area of study (e.g., mathematics) and general social norms, and then coordinates these with the psychological analysis of an individuals' general and mathematical beliefs. In an effort to explain what "focusing phenomena" are and the role that they can play in a classroom instructional environment, Lobato and colleagues (2003) published their account of some unexpected findings borne out of an empirical study of a reformed high-school mathematics curriculum. During the study, the researchers noted the presence of what they termed "focusing phenomena" (i.e., practices that direct attention to certain properties of a construct over others), which had unintentionally impacted the learning outcomes of an instructional unit teaching mathematical concepts.

At the outset of the study, Lobato, Ellis and Munoz (2003) were specifically interested in understanding how individual students' generalizations about slope (the rate of change of a linear function) were formed and supported as a result of student interactions with a curriculum that regularly developed concepts in real world settings. Slope, as a concept, was selected for the purposes of the investigation because it is conceptually complex, it has a number of real-world connections, and it is considered an important concept in the school's mathematics curriculum. Given the curriculum's real-world focus and tailored instructional design, Lobato et al. expected students to adopt the more generalizable conception of slope-as-a-ratio (i.e., slope as a rate of change of co-varying quantities in multiple real-world settings) as opposed to the more common (mis)conception of slope as a counting technique used to determine the steepness of a line in a coordinate grid system, the former affording greater potential for application than the latter. However, approximately half-way through the five-week study, which included data collection via semi-structured interviews with learners, and classroom videotape, Lobato et al (2003) were surprised to find that all of the students had adopted a slope-as-difference, rather than the desired slope-as-ratio understanding and were actively generalizing this understanding to novel settings. Lobato and her colleagues sought answers for this unintended outcome by re-considering the learning environment from an actor-orientated perspective.

To accomplish this, they designed an analysis protocol for classroom videotapes and interview transcripts in an attempt to understand how the classroom environment had created and was supporting these unpredicted conceptualizations of slope. The first phase of the analysis was to infer categories of meaning for slope in the students linear equations. Once identified, classroom videotape was analyzed to identify how the classroom environment may have supported the construction of these meanings, and finally, to look for "regularities in the ways in which the environment focused students' attention on certain mathematical properties" over others (p.10).

Results of Lobato et al.'s (2003) analysis indicated that the unexpected outcomes could be attributed to the presence of four "focusing phenomena" or observable features in the classroom environment that had acted to direct students' attention to information supporting the slope-as-a-counting technique. These include the mathematical language use in the classroom (e.g., the use of ambiguous language that could support multiple interpretations of slope); the curriculum material (e.g., the use of well-ordered tables that can mislead students); the use of artefacts (e.g., the ways in which graphing calculators were used); and the instructor behaviour (e.g., the emphasis on uncoordinated sequences and differences rather than the whole). The authors note that the concept of "focusing phenomena" explains or accounts for the multiple aspects of the learning environment, which work together to direct attention, guide abstraction, and help to create mental representations. Generalization then, as an extension of a mental representation or structure to a



new or different situation, can also be influenced by the nature of focusing phenomena. Lobato et al. concluded that changing the object of focus could improve learning and transfer outcomes.

Based on these and similar results, they make a case for a couple of instructional design considerations to be kept in mind when considering transfer of training. First, it is important to understand the nature of the transfer situations from the trainees' viewpoint, so that instructors are better able to help them develop the appropriate types of reasoning to transfer to novel situations. Indeed, the trainee plays a unique role in the learning experience as they structure their own environment so that this is congruent with learning objectives and motivations. And secondly, simply teaching for understanding in anticipation of transfer is in their mind far too general as an instructional guide to be useful. Again, like the preparation for future learning approach, the actororiented approach also requires further examination to be valid, but should no less be recognized as a useful perspective on understanding the nature of transfer and how this gets realized.

Transfer as Social Framing (or Intercontextuality) - A final alternative approach noted in the literature is the social framing or intercontextuality perspective. Like the PFL and actor-oriented perspective, Engle's (2006) intercontextual "situative" approach underscores the importance of sociocultural ideas and interaction theories for explaining the occurrence of transfer. Engle also argues that approaches that consider transfer merely in terms of having the right content to apply to a novel setting fail to consider the importance of both human agency and the participation in a wider social context. Transfer, she states, "involves not just knowing but doing, and that doing inherently involves an exercise of human agency. Thus, if transfer is going to happen...it is necessary that learners choose to use what they have learned...[and these] choices can be influenced by how learning and transfer contexts are framed socially" (p. 455). According to Engle, "social framing" can be understood in terms of sanctioning (i.e., the choices are socially acceptable or desirable in some way), in terms of future learning (i.e., learning environments vary to the extent that trainees are encouraged to consider learning for the future), and in terms of participation in a larger community of individuals engaged in an ongoing intellectual endeavour. Consideration of authorship in an intellectual community fosters social expectations, such as thinking intelligibly and sharing ideas. Such framing, Engle argues, helps produce intercontextuality. Ultimately, linking contexts for her makes the content from the learning context relevant to the transfer context, and this relevance produces a relationship between the two, making transfer more probable (Engle, 2006).

Her situated approach to transfer and learning lead to a model that combines analyses of the content with the context, as shown in Figure 17.



Figure 17. Structure of the situative explanation being investigated (Engle, 2006)

Because of the recent inception of this way of construing transfer (i.e., social framing or intercontextuality), there is limited empirical support. However, Engle herself has conducted an ethnographic study that does lend support for her particular conceptualization of transfer.

Specifically, content analysis involved understanding the learners' role in the construction of the content they are able to transfer. Context analysis involved examining the social contexts surrounding the learning and transfer events and analyzing how each is framed to create intercontextuality or connections between the contexts. Again, optimal transfer is thought to occur when learning contexts are framed to be part of larger ongoing activities of which learners play an integral role.

Engle's theory of social framing or intercontextuality is compelling. However, to date, there is little evidence to support it other than her ethnographical study. Like the PFL and actor-oriented alternatives to transfer of training, Engle's social framing approach should be considered for future research. Direct application theory and sequestered problem-solving approaches may be too isolated to show legitimate results of training. Using an ethnographic methodology is very time consuming, but it may show how individuals manipulate their learning environments in order to maximize training outcomes.

#### Discussion

The literature reviewed in this chapter included 3 models relevant to the transfer of training. These include Baldwin and Ford's (1988) seminal model positing key roles for training design, trainee characteristics, and workplace characteristics. The Learning Transfer System Inventory (LTSI; Holton et al., 2005) presents a comprehensive framework of transfer as part of a larger evaluation framework aimed at understanding and diagnosing causal influences at play in human resources development interventions. Another model by Colquitt et al. (2000) gives a central role to learning motivation in transfer. In general, there is a good level of commonality among the most prominent models of transfer (Baldwin et al., 1988, Colquitt et al., 2000 and Holton, 2005) with many of the



same factors being posited as influences on transfer. For example, all 3 models posit an important role for characteristics of the trainee, the design of training and the impact of the work environment. The motivation of the trainee to learn is a theme that is consistent within the models in this section, as well as one of the rare characteristics that researchers seem to agree promotes better levels of transfer (e.g., Blume et al., 2010). This issue will be explored more in the upcoming section related to characteristics of the trainee.

Three alternative approaches to thinking about transfer argued that conceptualizing transfer solely in terms of a specific task may not be optimal. The alternative models of transfer seem aimed at correcting the fairly narrow way in which transfer has typically been conceptualized. These models adopt non-experimental approaches, and take a much broader view, and derive more from the learning domain than the training domain. However, these models do not appear to have been validated, particularly using experimental approaches.

In the end, both approaches to understanding transfer seem to offer important information about the nature of transfer. It does seem important to remember that transfer is partly a product of the environment in which it occurs, and that it cannot fully be separated from the motivation and ability of the person.



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## Annex B - Transfer of Training Research

This section considers a range of factors posited to influence transfer of training within the workplace and the empirical data supporting them. These include the design of training, workplace environment factors, and characteristics of trainees. To varying degrees, all of these factors have been shown to influence transfer and the sections that follow review relevant research in this area.

A recent effort by Blume, Ford, Baldwin and Huang (2010) is also particularly helpful for understanding the trends within this large area of research. They conducted a meta-analysis to quantify the relative influences of a range of factors on transfer of training outcomes. Analyses were conducted on 89 field and laboratory studies exploring a number of key trainee characteristics (e.g., cognitive ability, experience, personality and motivation) and several other areas (e.g., work environments) and their relative impacts on transfer of training. Results of this meta-analysis are explored in the sections that follow.

#### **Training Design**

It seems logical to expect that how training is actually designed will influence transfer of training. The importance of training design is captured in Baldwin and Ford's seminal 1988 model, which emphasizes the role of training inputs. Baldwin and Ford (1988) note 4 basic principles relevant to research exploring training design. These include identical elements (transfer will be better with identical stimuli and response elements in training and transfer settings), the use of general principles in training, stimulus variability (using varied rather than constant stimuli) and the conditions of practice (e.g., massed or distributed training, whole or part training, feedback or overlearning).

Previous research has explored the impact of using <u>principles</u> during training. To explore the impact of expertise and schema utilization on promoting transfer, de Croock and van Merrienboer (2007) examined the impact of different training approaches. They point out that the nature of expertise has been changing. As repetitive tasks are progressively being automated by computerized production systems, today's workers are increasingly faced with novel situations and work tasks. This reality requires them to solve new problems and apply their skills in ways never before required. This suggests that a different approach to training design may be beneficial—one that focuses on the application of acquired knowledge to new situations, rather than on the fast acquisition and application of skill. The ability to adapt and demonstrate flexibility in one's behaviour (as required by the dynamic nature of work) has been termed "reflective expertise" (Olsen & Rasmussen, 1989; cited in de Croock & van Merrienboer, 2007).

De Croock and van Merrienboer argue that training instruction must work to promote two types of learning processes. These include elaborative encoding, defined as "a result of which presented information is linked to already existing schema" (p. 1742) and inductive processing, defined as when "new schemata are formed on the basis of concrete learning experience, or, existing schemata are modified to make them more in accordance with new experiences" (p. 1742). Some research has shown that an inquisitory approach to learning can promote more elaborate encoding of presented information (De Jong & Van Joolingen, 1998, cited in de Croock & van Merrienboer, 2007). This approach involves the explicit presentation of system principles, followed by the learner constructing examples that demonstrate the application of system principles to predict or explain system behaviour, as well as demonstrations about how general strategies can be used in



conjunction with causal reasoning. In the expository approach to training, on the other hand "both system principles and examples of their application are explicitly presented to learners" (p. 1742). Simply presenting principles and examples rather than prompting trainees to actively construct their own views of the problems was argued to be less effective at promoting less elaborated schemas. To facilitate expertise advancement, the instruction provided to participants aimed to promote two learning processes previously shown to support successful transfer performance: (1) elaborative encoding intended to facilitate transfer by linking new information to existing schemas; and, (2) inductive processing, which builds new schemas (or modifies existing ones) based on concrete learning experiences (van Merrienboer, Clark, & de Croock, 2002, cited in de Croock & van Merrienboer, 2007).

De Croock and van Merrienboer (2007) were interested in assessing whether their modified instructional design for creating reflective expertise (by eliciting elaborate encoding and inductive processing) was more effective than the more traditional (learner as passive recipient of information) instructional design for facilitating transfer to novel situations. Second, research in other areas (e.g., verbal, psychomotor learning) has shown that approaches to instruction that incorporate high contextual interference (i.e., when practice occurs under various conditions that interfere with skill acquisition), are more likely to promote inductive processing in learners than low-context interference conditions (e.g., Wulf & Shea, 2002, cited in de Croock & van Merrienboer, 2007). Combining these two findings, then, they expected that participants trained using an inquisitory approach and a high level of contextual interference would develop more elaborated cognitive schema because they would be thinking more in terms of violations of systems principles. People trained in the traditional expository means and under low contextual interference would stay more bound to the current context, and this would hinder their ability to transfer to new situations.

These ideas were tested by presenting participants with a troubleshooting task. Participants in this study were encouraged to apply a general troubleshooting strategy to a malfunctioning system designed to distil alcohol. They were first provided with an opportunity to develop a basic level of system knowledge (e.g., by providing information about the system's operating principles).

To test whether or not the modified instructional design was an improvement on the traditional approach, undergraduates (n = 69) were asked to practice and then were tested using their newly developed troubleshooting skills for a simulation exercise within an alcohol distillery plant. This research used a 2 (inquisitory vs. expository training) x 2 (contextual interference: high vs. low) factorial design. To begin, participants were presented with information about the distillery system. In the <u>expository condition</u>, participants were provided information about, and examples of, how each component controlled a valve in various states of operation. In the inquisitory condition, participants were required to guess (using multiple choice and practical application) how each component controlled the valve during different operating states and were always shown the correct answer and an explanation following each guess. For example, participants had to guess how a specific action would impact the distiller, either by selecting the answer via multiple-choice or testing it on a computer simulation.

Once the initial information presentation had concluded, the practice session began. Participants were tasked to troubleshoot 20 cases of four types of malfunction. Participants in the inquisitory condition were required to show a demonstration for each type of malfunction (e.g., how to correctly diagnose the problem by applying a general troubleshooting strategy). Contextual interference was varied, with half receiving the 20 cases in a random order (high interference), and



the others receiving five cases of the same type of malfunction before moving to the next (low interference).

After completing the practice session, participants' ability to transfer their new knowledge was tested by two tasks. The first presented them with eight novel malfunctions of the same distiller system used in the practice session (Distiller 1). Two weeks later, participants were presented with a different distiller system (Distiller 2) along with information describing its new components. Their task was to diagnose seven malfunctions - the same malfunctions as those encountered during the first transfer task (using Distiller 1). In each transfer task, participants were required to manipulate the controls of the system in order to diagnose the type of malfunction and were measured on mental effort and performance.

Relative effectiveness was measured by comparing the quality of learners' schemas following a series of practice sessions. High quality schemas were expected to produce more accurate answers in less time than low quality schemas (Swaak & De Jong, 1996, cited in de Croock & van Merrienboer, 2007). To assess the quality of the schemas, learners were shown a snapshot of a distiller (the same one as used in a practice session) and asked a number of questions intended to tap their knowledge of the distillery system (i.e., the status of the distiller after specific actions were performed, controlling a malfunction, and causes for system failure). Answers needed to be given as quickly and accurately as possible, and transfer was assessed as the total number of correct items and the average time required.

Results from the first transfer task showed no significant differences in transfer as a product of time, the number of correct or incorrect cases, diagnosis time, or invested mental effort across conditions.<sup>9</sup> However, non-significant trends showed that participants in the expository condition were able to diagnose cases faster than participants in the inquisitory condition, and somewhat fewer incorrect diagnoses were made in the high interference than low interference condition. However, these trends were eliminated with the second transfer task (two weeks later), as results totally contradicted their original predictions. Specifically, participants in the inquisitory condition experiencing high interference condition required significantly more time to finish the task (showing lower levels of transfer) than those in the expository and low interference condition.

Results also showed no significant differences in schema creation between groups. Thus, the hypothesis that high quality schemas would promote better transfer of training was not supported. And, there was no evidence that high contextual interference would further promote better schemas. De Croock and van Merrienboer contend that an insufficient amount of practice time may have prevented these schemata from fully forming, leaving them fragmented, and limiting their usefulness to transfer to new situations (Distiller 2). Secondly, they suggest that the combination of the demanding inquisitory approach paired with high contextual interference could have proved too cognitively demanding for users to reason causally. De Croock and van Merrienboer suggest that future research designs should incorporate more opportunity for practice to properly establish

<sup>&</sup>lt;sup>9</sup> Results from the practice session indicated that participants experiencing high interference (i.e., the inductive processing promoting condition) required more time to complete the practice cases than those in the low interference condition. In line with de Croock & van Merrienboer's (2007) predictions, high interference participants reported greater mental effort ratings in addition to making more incorrect diagnoses than participants experiencing low interference. Likewise, participants in the expository condition needed more time to complete the practice cases and made more incorrect diagnoses than those participants in the inquisitory condition who were required to describe the component functions. Furthermore, participants who experienced high interference and were asked to describe the component functions solved fewer cases than participants who had experienced low interference.



schemas that can be exercised in transfer situations. Although the logic underlying their general premise seems sound, their instantiation of the inquisitory and expository approaches may offer a more parsimonious explanation for the failure of this research.

DeCroock and van Merrienboer (2007)		
Methodology Used	Problem solving task – distillery	
Source/Cue/Training	Practice cases with Distiller 1	
Probe/Test/Outcome	Transfer test I – 8 cases with Distiller 1 (immediately after) Transfer test II – 7 cases with different Distiller 2 (2 weeks after)	
Independent Variables	Levels of contextual interference (high or low) Type of training (inquisitory or expository)	
Dependent Measures	Quality of the schema (ability to answer questions about Distiller 1 in frozen state - speed and accuracy) – 19 questions, each with 3 choices Transfer tests – time on test, % of cases directly diagnosed, mean number of incorrect diagnoses, mean diagnosis time, mean mental effort for diagnosis (self report of cognitive load)	
Findings	Expository training and low contextual interference promoted marginally better transfer and required lower levels of effort However, no differences in schema quality as result of training	

#### Table 21. DeCroock and van Merrienboer (2007)

Research by Bell and Kozlowski (2008) explored a range of impacts on active learning processes and transfer. This work also emphasizes the self-regulatory processes that influence learning. Participants were trained to undertake a complex computer-based simulation. This work addressed the impact of 3 training design elements, including whether training was exploratory (emphasizing the active learning of the trainee) or proceduralized learning (passive). How errors were framed was also manipulated, with half of participants being told that errors were a helpful and natural part of any training activity, while the other half was told they were negative and should be avoided. Some participants were also provided with emotion control strategies that provided them with strategies to keep their emotions in check. The design used, then, was a 2 (type of training: exploratory or proceduralized) x 2 (error framing: positive or negative) x 2 (emotion control strategy: yes or no) fully crossed design. Performance on the task was measured at 3 points, including after the final practice trial, after completion of a similar task (analogical transfer performance) and after completion of a more difficult and complex task (adaptive transfer performance).

Results showed significant differences in performance at each distinct measurement phase. Immediately after completion of training, trainees in the proceduralized condition showed better performance than those who received exploratory training. However, on both the analogical transfer task and the adaptive performance task, trainees who experienced exploratory learning performed better than those with proceduralized learning. This effect is noted to have been seen in other literature (e.g., Schmidt and Bork, 1992; cited in Bell and Kozlowski, 2008), and is called the cross-over effect. This means that the benefits of training strategies show up on the transfer task, but not necessarily during the immediate stages of training. Other analyses showed error framing to have no impact on post-training performance and measures of analogical transfer. On adaptive performance measures, trainees with the positive error frame were marginally more effective. Emotional control had no impact.


Bell and Kozlowski, 2008				
Methodology Used	Radar tracking simulation – hooking contacts, collecting information and classifying			
Source/Cue/Training	Familiarization training, followed by practice – three blocks consisting of 3 – 8 minutes trials			
Probe/Test/Outcome	Training transfer task – 2 additional trials			
	First trial was analogical transfer (equivalent difficulty to training trials)			
	Second trial was adaptive transfer – more difficult, complex and dynamic than practice trials			
Independent Variables	2 (Type of instruction: exploratory learning or procedural instruction) x 2 (Error framing: errors encouraged as part of learning or error avoidance: errors are detrimental) x 2 (Emotion control strategy: Strategies provided or not)			
Dependent Measures	Skill based performance – number of correct identifications minus errors Pre – cognitive ability, trait goal orientation, trait anxiety, metacognitive activity, self- evaluation activity, state goal orientation, intrinsic motivation, self efficacy, state anxiety, declarative knowledge			
Findings	Trainees receiving exploratory instruction showed worse performance during training but better analogical transfer and better adaptive transfer Trainees working with a positive error frame showed better adaptive performance However, emotion-control strategies did not directly impact on performance, but did lower anxiety			

#### Table 22. Bell and Kozlowski (2008)

This study suggests that exploratory learning may have a somewhat latent effect, and comes to positively influence transfer performance after initial training has been completed and skills are actually put to the test.

Moran, Bereby-Meyer, and Bazerman (2008, p. 102) examined the effectiveness of various training methods and the incorporation and use of integrative learning principles (i.e., principles that emphasize mutual benefits and win-win scenarios rather than competition for resources) in achieving transfer across different negotiation scenarios. The researchers predicted that the learned level of abstraction and the ability to generalize from training examples would be affected by the diversity of analogical exemplars that negotiators encountered during training.

Participants in this study were taught general principles of integrative-negotiation (e.g. "value can be created" and "the pie is not necessarily fixed and can be expanded in various ways") through exposure to five value-creating negotiation strategies. Identifying and learning the principles underlying integrative thinking was expected to support their transfer to more widespread and varied negotiation tasks. Specifically, the researchers hypothesized that generalizability of learning would be highest when individuals observed multiple negotiations using different value-creating strategies and lowest when individuals observed multiple negotiations exhibiting the same value-creating strategy. The hypothesis was tested in two empirical experiments, in which learners followed a facilitative guidebook to compare and contrast two negotiation cases presented simultaneously.

In the first experiment, undergraduates (N=116) were randomly assigned to one of three betweensubject conditions: a <u>specific training</u> condition, in which participants compared two cases which employed the same value-creating strategy; a <u>diverse training</u> condition, in which participants compared two cases using two different value-creating strategies; and a <u>control condition</u>, in which



participants received no negotiation training. Participants in both experimental conditions participated in an instructional phase and were given a questionnaire that asked them to (a) "compare the cases; (b) evaluate, compare, and contrast the proposed optimal agreements; and (c) identify an underlying principle that captures the essence of both strategies" (Moran et al., 2008, p. 106). Participants in the control condition participated in a task that was cognitively demanding but irrelevant. Immediately following instruction, participants within each condition were randomly paired together and engaged in a multi-issue negotiation (the transfer task), designed to allow for the use of value-creating strategies that were taught during the training phase, as well as other strategies which were not. Effectiveness of the training programs was determined by evaluating the negotiation outcomes (including the joint gains achieved by the dyad), and the participant's depth of understanding of the potential to create value in negotiations (as represented by a composite "understanding score" rated by coders) based on their verbal explanations about the negotiation.

Results of Moran et al.'s (2008) study showed that individuals provided with diverse training (relative to specific training and no training) achieved negotiated outcomes characterized by higher joint gains, greater use of previously untrained value-creating strategies, and a deeper understanding of the value-creating potential of integrative negotiations. Moran and colleagues argued that analogical training of diverse cases seems to facilitate transfer by promoting broader value-creating strategies and a better understanding of how to create value during negotiations. As such, they concluded that better performance by participants who received diverse training was exhibited by their "win-win perceptions about negotiation and their deeper understanding of the potential to create value" (p. 121). This shows that comparing and contrasting diverse cases simultaneously is more effective at promoting transfer of negotiation skills than comparing single cases.

Moran et al. (2008) – Experiment 2 only				
Methodology Used	Contingent contracts			
Source/Cue/Training	Read 2 cases in the learning phase – for both specific training and diverse training, Case 1 addressed logrolling. Case 2 used logrolling in specific training and contingent contract for diverse training – asked to compare and identify common principle			
Target/Test/Outcome	Complex integrative negotiation contract task requiring contingent contract, logrolling, time trade-off etc.			
Independent Variables	Specific training (logrolling) or diverse training (logrolling and contingent contract)			
Dependent Measures	Level of understanding (e.g., use of principles) Outcome of face-to-face negotiation Questionnaire exploring general assumptions about negotiations			
Findings	Significantly better negotiation outcomes in the diverse training case than in specific training case, better contracts, better grasp of general principles and concepts			

Table	23.	Moran	et al.	(2008)
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Research has also been devoted to understanding the role of the <u>conditions of practice</u> (e.g., massed or distributed training, whole or part training, feedback or overlearning) in transfer. One of the common themes in the training literature relates to the importance of feedback. Ansburg and Shields (2003) considered the importance of feedback during training as a mechanism to facilitate transfer, especially when participants compared different problems rather than similar problems. They believed that having participants complete a problem comparison task (which included strategic



instructions as part of the training) would promote greater generalization and hence transfer. They examined the transfer of deductive reasoning principles on the Wason's selection tasks. Wason's selection task (also called the Four Card Selection problem) requires people to use conditional reasoning skills to validate a given rule in the problem, when the problem contains either thematic or arbitrary content. Thematic rules contain elements that are consistent with everyday experiences (e.g., If you eat your dinner, then you can have dessert), whereas arbitrary rules are not consistent with these experiences (e.g., If you drink pop, you will hear a bell). Although solving both types of problems requires the application of the laws of inference, people have a tendency to do far worse on arbitrary problem-solving than on thematic problem-solving (Manktelow, 1999, cited in Ansburg & Shields, 2003). According to some researchers (Cheng & Holyoak, 1985, Griggs & Cox, 1982, both cited in Ansburg & Shields, 2003), thematic rules promote more logical solution paths because they help people to draw on their domain-specific experiences.

Arguing that both thematic and arbitrary problems require similar operations to solve (i.e., modus ponens), Ansburg and Shields (2003) wondered whether training on one type of problem would enable transfer to another. Previous research has shown that learning about arbitrary problems transferred to thematic problems (Klaczynski, Gelfand, & Reese, 1989, cited in Ansburg & Shields, 2003), but transfer from thematic problems to arbitrary problems was dependent on the kind of thematic problem used (Klaczynski 1993, cited in Ansburg & Shields, 2003). However, thematic problems that use causal rules (e.g., "If some event occurs, then some outcome will result.") and permission rules (e.g., "If some action is taken, then some precondition is met") (Cheng & Holyoak, cited in Ansburg & Shields, 2003) have shown varying effects. Practicing causal problems with feedback facilitated transfer to arbitrary problems, but this was not true for permission problems (Klaczynski 1993, cited in Ansburg & Shields, 2003). Ansburg and Shields argued that this was because solving causal problems requires developing abstract rules rather than a more specific causal schema, which they argue is inadequate. They argue that learning general solution problems (i.e., domain-general rules) rather than specific problem content should provide the decontextualization necessary to transfer from the source (i.e., permission or causal problems) to arbitrary problems (target). Research has shown that people who can readily decontextualize are more adept at solving problems (Sa, West, & Stanovich, 1999, cited in Ansburg & Shields, 2003). Training participants to see the underlying structural features of the problems through problem comparison, then, should promote transfer.

To test their hypothesis, Ansburg and Shields (2003) conducted a 2 (feedback: present or absent) x 2 (problem comparison: yes or no) x 2 (order of practice problems: forward or backward) factorial design with undergraduates (n = 69). In the initial practice phase, all participants received six permission problems (e.g., Four Card Selection task). The order of these problems varied for each participant. Participants were put into four training conditions: feedback only; problem comparison only; problem comparison plus feedback, and control. In the feedback only condition, participants solved each permission problem and were read an in-depth explanation of the correct solution after each of the 6 problems. In the problem comparison only condition, participants read 2 solved permission problems and then read strategy instructions for Wason's selection task. Participants were then asked to label the problem elements in abstract notation and write out a strategy (or rule) also using notation that would help them resolve the problem. Any errors were corrected by the experimenter. Participants compared the problem with each successive permission problem. Participants in the feedback plus problem comparison condition solved each permission problem and were read an in-depth explanation of the correct solution after each of the 6 problems. They also compared each problem to the one preceding it, such that a problem comparison was done for each of the 6 permission problems. They also received feedback as part of their training.



Participants in the practice <u>control condition</u> solved each of the 6 permission problems without comparison problems or feedback. To determine whether participants actually learned general deductive reasoning principles that they could later transfer to solve other problems (arbitrary problems), participants in all conditions were required to solve 5 arbitrary problems.

Results showed that the mean solution rates were significantly higher in the problem comparison plus feedback condition than in the practice control condition.<sup>10</sup> They reasoned that participants in the problem comparison plus feedback condition "learned to note similarities among the practice problems" (p. 238). In terms of the impact of feedback, participants who received problem-specific feedback were unable to transfer from permission to arbitrary problems. Problem-specific feedback did not permit the development of general rules for problem-solving, because participants relied on "a pre-existing permission schema" (p. 239). They argued that overreliance on this schema muted participants' ability to adjust their understanding and adapt to new kinds of problems. As such, Ansburg and Shields suggest that participants gaining problem specific feedback favoured surface features over structural features, and this subsequently hindered their capacity to generalize. On the other hand, their study did demonstrate that the problem comparison method with solution strategies underscored the structure features of problems irrespective of context (i.e., permission vs. arbitrary problems). Participants who were asked to compare problems and read strategy instructions were able to transfer to different kinds of problems. Results showed that participants with comparison training resolved more target problems, suggesting it had an impact on developing domain-general rules for problem-solving. Ansburg and Shields suggest that feedback that included strategy instructions and was schema inconsistent may promote the development of domain-general rules and hence transfer across varying problem contexts. Overall, they suggest that the technique used in their experiment may have resulted in the development of more comprehensive mental models, which in turn would lead to a more successful and complete search for solutions. However, the presence of mental models was not directly explored.

Ansburg and Shields, 2003			
Methodology Used	Problem solving task – permission type of the Wason Four-Card problem		
Source/Cue/Training	Six permission problems		
Probe/Test/Outcome	Five arbitrary problems		
Independent Variables	2 x 2 x 2 factorial design – feedback (present or absent), problem comparison (yes or no), order of practice problems (forward or backward)		
Dependent Measures	Solutions to five arbitrary problems		
Findings	Participants who performed problem comparison and received feedback on permission problems did better at solving problems (relative to control group), but this is not transfer to solving arbitrary problems		

Table 2	24. /	Ansburg	and	Shields	(2003)
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Another critical aspect of training is whether it addresses the entire task or simply one part of the task. Goettl and Shute (1996) explain that part task training is commonly used for complex manual control and tracking tasks, on the assumption that training on component parts will allow people to exhibit a more complex skill. This prediction is predicated on assumptions about the nature of

<sup>&</sup>lt;sup>10</sup> The problem comparison condition was excluded from analyses, as no participants attempted to generate solutions to problems.



cognitive skills (Carlson, Khoo and Elliott, 1990; cited in Goettl and Shute, 1996), namely that complex skills are multidimensional and are linked by organizing strategies, that cognitive capacity has limits, and that fluency on component parts is critical to completing the more complex task. This assertion, however, is somewhat at odds with reviews conducted during the 1980s which that are argued to have shown (Wightman and Lintern, 1985; cited by Goettl and Shute, 1996) little consistent support for the efficacy of part-task training.

At training, a whole-task group receives training on the criterion task and the part-task group receives training on the component tasks. The potential value of part-task training is it can help those individuals who have low-aptitude cope with the demands of the whole task (Goettl & Shute, 1996). Unlike traditional transfer paradigms, Goettl and Shute (1996) used a backward-transfer paradigm to examine the differences of part-task versus whole-task training for a desktop flight simulator. A backward-transfer approach involves training the final segment in a series first, followed by the addition of a preceding task and so on until all tasks have been "chained" together. "Backward transfer to the component tasks", they explain, "can be estimated by comparing the transfer performance of the whole-task group with the initial training performance of the part-task group. Component tasks showing positive backward transfer involve skills presumably acquired by the whole-task group during training and thus are critical to the whole task" (Goettl and Shute, 1996, p. 230). Goettl and Shute wanted to examine the merits of backward-transfer for developing effective part-task training and examine differences in spatial ability when learning complex spatial tasks. To accomplish this, they conducted two experiments. Transfer is examined in terms of application of the component tasks (i.e., pitch and roll, unpitch and unroll spatial orientation, etc.) to the criterion task (i.e., flying the simulator through gates in the sky). At the transfer test, both groups are tested on the component tasks and not the criterion task.

The first, using the flight simulation as their test bed, Goettl and Shute (1996) combined a backward-transfer approach with the typical transfer of training design. Their goals were to reveal the effectiveness of part-task training compared to whole-task training; isolate the component tasks and indicate their relevance to the criterion task; and examine the relationship between training method and spatial ability (i.e., working memory, information processing, and inductive reasoning). The <u>whole-task group</u> received training on the criterion task, followed by a transfer phase on the criterion task, and then a backward-transfer phase on the component tasks. On the other hand, the <u>part-task group</u> received training on the component tasks (providing this group with the opportunity to eliminate irrelevant tasks during the backward-transfer training). They argued that this design allowed them to estimate not only the difference between the two groups capacity to transfer form the whole task to the component tasks.

Results of the first experiment indicated that the part-task group showed some transfer but still had lower performance than the whole-task group. However, backward-transfer analysis revealed some component tasks were more critical to the criterion task than others, suggesting that overextending one's attention to all component tasks (including irrelevant tasks) may not spark learning benefits for effectively accomplishing the criterion task. The second experiment again used a part-task training regime (using component tasks shown to be critical in the first experiment) and compared it to whole-task training and another part-task training regime consisting of non-critical component parts. Goettl and Shute (1996) found that the critical part-task training was as effective as the whole task regime. Results also showed those with low-aptitude improved their performance from the first experiment to the second experiment. This might have occurred because removing "deadwood" tasks from part-task training helps facilitate learning, and these benefits are especially



relevant to trainees with lower aptitude. These results demonstrate the utility of the backwardtransfer design in understanding the merits of learning from part-task training compared to wholetask training.

Goettl and Shute (1996)	
Methodology Used	Instructional training on computer task
Source/Cue/Training	Training on criteria task (flying the simulator through gates in the sky) or training on component tasks (e.g., pitch and roll, unpitch and unroll, spatial orientation)
Probe/Test/Outcome	Transfer test – ability to complete criterion task, flying the simulator through gates in the sky (speed and accuracy) Backward-transfer test – transfer on component tasks, identifying critical vs. non- critical tasks
Independent Variables	Whole-task vs. part-task instruction
Dependent Measures	Skill acquisition – part-task achievement test and whole-task achievement test Transfer test – ability to complete criterion task, flying the simulator through gates in the sky (speed and accuracy) Learner spatial aptitude
Findings	The part-task group showed some transfer but performed worse than the whole- task group Backward-transfer analysis revealed some component tasks were critical to the criterion task over others Critical part-task training (i.e., eliminating irrelevant component-tasks in the training) was as effective as whole-task training Low-aptitude participants improved from experiment 1 to experiment 2 after removing non-critical component tasks from the training

Table 25. Goettle and Shute (1996)

Research from the educational domain also explored the impact of part-task versus whole-task training (Lim, Reiser and Olina, 2009). They explain that traditional design methods have used an "atomistic" approach. The "atomistic" or "part-task" approach relates to meeting objectives through completion of a small task. They argue that this type of approach leads to fragmented training and trainees may experience more difficulty transferring into new situations. This is especially true for complex cognitive tasks that demand high-level schema activation and conscious processing, such as the mapping of correspondences. As previously mentioned, schemas are argued to promote adaptation in one's environment. Since the "part-task" training method does not require the learner to activate a comprehensive schema representing the whole problem area (only "parts" of the training content), it may not be ideal for training complex tasks.

Lim and colleagues proposed a new method of training known as "whole learning task" called van Merrienboer's (1997) Four Components Instructional Design Model (4C/ID-model).which they suggest is better suited to the instructive training of complex tasks. This method, they argue, would allow for the transfer of the knowledge, skills, and attitudes developed in training to real world situations. This model has four components: learning tasks, supportive information, procedural information, and part-task practice. Learning tasks in the whole-task approach are concrete, real, and meaningful. These tasks can be problems, activities, case studies, etc. Moreover, it is suggested that learning tasks should show high variability in order to promote schema creation. Supportive information is provided to the participants before they engage in a task to foster desired learning.



such as reasoning and problem-solving. Procedural information is provided during or just before a task to substantiate specific task rules and procedures. Lastly, part-task practice is for those skills that require automaticity. The part-task practice occurs after the learner has practiced the whole task. They argue that the 4C/ID model is the ideal instructional method for transfer of training because it emphasizes whole-task practice; promotes integration, coordination, and understanding of complex skills; uses task variability; and promotes schema creation.

Lim and colleagues (2009) investigated the effectiveness of the whole-task approach. Their research compared the outcome of complex skills training using either part-task or whole-task training methods. Undergraduates studying to become teachers participated in a 2 (task instruction: whole vs. part) x 2 (knowledge level: high vs. low<sup>11</sup>) experimental design. Participants were given two 1-hour lessons on how to create an Excel grade book. For each lesson, the instructor began by presenting participants with the topics that would be covered in the lesson, a general overview, and the concepts and skills they would be taught. Participants were also shown examples of Excel grade books. After this, participants began the second part of each lesson which varied based on condition. Participants in the part-task condition received training on 22 skills about how to prepare an Excel grade book (e.g., data entry, merging cells, etc.). Participants were asked to practice the skills after each skill was presented. After each skill was trained and practiced, participants completed 20 practice activities. In lesson 1, these practice activities were basic (e.g., enter data), whereas, in lesson 2, these activities were more advanced (e.g., write a formula). Participants in the whole-task condition were given a modelling example describing how to create an Excel grade book. Participants were asked to create the same Excel grade book the instructor had demonstrated. Following this, participants were asked to create another Excel grade book with a new set of data and without the instructor's demonstration. The instructional method for participants in the wholetask condition was based on the 4C/ID model. For example, participants were given supportive and procedural information. Supportive information was given at the start of the second part of the second lesson in the form of example descriptions. Procedural information was provided when needed. Once participants in both conditions completed both lessons, they were asked to create a new Excel grade book using the data provided. They also reported the start and end time of the entire training exercise.

Two days after the initial training, participants completed two achievement tests, as well as a transfer test and their attitudes were also assessed. One of the achievement tests was a part-task test and measured participant's performance on 16 separate skills. The other achievement test was a whole-task test which measured participant's performance on preparing a grade book and incorporating specific features in the book. The transfer test required participants to prepare a budget with the data provided. The transfer task incorporated the features that were taught during the training, but which were presented in a new context. Some of the features were able to be scored as correct or incorrect, while others required a scoring rubric on a 3 or 5 point scale. Attitudes were measured using a 30-item questionnaire adapted from the Instructional Material Motivational Survey (Keller, 1993, cited in Lim et al., 2009) using a five-point agreement Likert scale. These items assessed participant's attention, relevance, confidence, and satisfaction with the training exercise.

<sup>&</sup>lt;sup>11</sup> Participants had been rated was having either high or low prior knowledge. Participants who performed 6 of the 16 skills were classified as having high prior knowledge, while the other participants were rated as having considered low prior knowledge.



Results of Lim et al.'s (2009) study showed that participants in the whole-task condition showed higher rates of transfer than participants in the part-task condition. Specifically, whole-task participants scored higher (86%) on the budget preparation task than part-task participants (68%). Participants with higher knowledge before the training scored higher on the budget preparation than participants with lower knowledge. One specific skill involved choosing the appropriate chart for the budget task. Participants in the whole-task condition were more likely to pick the appropriate chart than participants in the part-task condition. Although both groups performed well on both achievement tests, participants in the whole-task test. Moreover, more knowledgeable participants.

Overall, participants in both groups reported consistently positive attitudes about the Excel training Participants with higher knowledge before training were more confident about their training than participants with lower knowledge. Moreover, participants with more knowledge prior to the training did not show the expertise reversal effect. Training participants using a whole-task method was most beneficial in promoting transfer of training.

Lim and Reiser (2009)	
Methodology Used	Instructional training on computer task
Source/Cue/Training	Demonstration of 22 skills required to prepare a grade book in Excel
Probe/Test/Outcome	Transfer test – ability to complete new task not instructed in previous training – completion of Excel budget
Independent Variables	Whole task vs. part task instruction Level of learner prior knowledge (high vs. low)
Dependent Measures	Skill acquisition – part-task achievement test and whole-task achievement test Transfer test – ability to complete new task not instructed in previous training – completion of Excel budget, time on test Learner attitudes
Findings	No impact of prior knowledge Learners instructed in whole-task approach showed better performance on the whole-task test, and equally well on the part-task test These learners were also better able to transfer their knowledge to a new untrained task (e.g., Excel budget) Positive attitudes on the part of all learners

Table 26. Lim and Reiser (2009)

This research, then, provides evidence from the educational domain that whole-task training may facilitate transfer of learning. Like many transfer researchers, Lim and colleagues suggest that whole-task training promotes rich schema development, thereby facilitating the transfer of skills. Unfortunately, although they speculate that schema development might underline the transfer results, actual schema development is not tested in this research. A key issue, however, is whether this research would generalize to more complex settings and tasks.



### **Work Environment Factors**

Factors within the work environment have also been shown to influence transfer of training. These include the transfer climate within the organization and the social supports available to personnel within the environment. Transfer climate is noted in the literature to influence the ability of trainees to parlay their new skills to their actual workplace environment. A positive transfer climate can be described as one containing characteristics that help to shift what has been learned in training into the job situation (e.g., overt managerial and peer support, feedback, performance appraisal systems—including goal setting—accounting for behaviour and skills acquired from formal training programs, etc.).

Social supports are also commonly noted in the literature as being influential to the transfer of training. The presence of factors such as a positive attitude about the transfer of valuable knowledge and skill to the job context, supportive supervisors and co-workers who encourage transfer goals and provide feedback about trainee progress can all contribute to a positive workplace transfer climate. At the organizational level, a supportive workplace transfer climate can be nurtured by a company that espouses an organizational culture that values continuous learning and development among its employees.

It is worth noting that despite the clear assumption that factors within the work environment would influence transfer of training, in 1988, Baldwin and Ford argued that evidence for this assertion was sparse at that time. Baldwin and Ford (1988, p. 85) also caution that the presumably "strong' support for the importance of environmental characteristics to transfer is based solely on correlational studies in which causality can not be inferred". They also note that reliance on self report measures within this domain of research is also problematic. Despite some evidence showing the role of social support in transfer, research as a whole is mixed and inconsistent (e.g., Cheng et al., 2008).

This negative characterization of the work environment literature pointing 1988 seems to have been at least partly remediated in the years since then. A more recent meta-analysis by Blume et al. (2010) helps to firmly establish the importance of two work environment factors, namely transfer climate and social supports. The positive significant correlation of each of these constructs with transfer is shown in Table 27.

Trainee Characteristics	R with transfer
Transfer climate	.27
Support (supervisor .31 and peer support .1412)	.21
General environment	.22

Table 2	7 Work	onvironmont	factors	influoncing	transfor	(Rlumo of	Ы	2010)
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These work environment factors is described in more detail in the sections that follow.

**Transfer Climate** - There is some evidence that transfer climate impacts on transfer of training (e.g., Cheng and Hampson, 2008). Research by Tracey, Tannenbaum and Kavanagh (1995) examined the influence of the work environment on transfer of training in terms of the impact of organizational climate and a continuous-learning culture. They predicted that a transfer of training climate and a continuous-learning culture should facilitate transfer from training to actual

<sup>&</sup>lt;sup>12</sup> Small sample sizes, so caution is necessary.



behaviour. Specifically, culture and climate were hypothesized to have both direct and moderating effects on post-training behaviours.

This study was conducted in a privately owned supermarket chain. In total, 505 managers from 52 stores participated in a 3-day off-site supervisory skills training program focusing on interpersonal skills training and various administrative procedures. Three weeks prior to training, a measure of supervisory behaviours was collected from the trainee's supervisor. As well, pre-training knowledge was assessed using a supervisory knowledge test derived from content analysis of training materials. These measures served as a baseline indicator of supervisory behaviour and knowledge. Training methods consisted of lecture, discussion and demonstration, role-plays, and audiovisual techniques. As part of the program, participants were provided with opportunities to apply newly learned skills to realistic situations (i.e., role-play sessions) and receive feedback about their behaviour. At the conclusion of the training program, participants completed a transfer of training climate and continuous-learning culture measure. Seven weeks later, participants' supervisory behaviour and supervisory knowledge was assessed for a second time using the same techniques and measures that were used in the pre-training assessments.

Results showed that characteristics of the work environment impacted managers' application of newly acquired behaviour and skill. Transfer of training climate was found to have a direct impact on expression of post-training behaviours, and continuous-learning culture was also found to directly influence post-training behaviours. There was no evidence of indirect or moderated relationships.

However, despite good evidence in support of the role of transfer climate, in a recent review of the training literature, Aguinis & Kraiger (2009) have argued that research as a whole is mixed and inconsistent, with studies showing both positive (e.g., Richman and Hirsch, 2001; cited in Aguinis and Kraiger, 2009) and null effects (e.g., van der Klink et al., 2001; cited in Aguinis and Kraiger, 2009). These inconsistencies and disagreements permeate the transfer literature.

**Social Supports** – There is also considerable agreement in the literature about the importance of social supports in transfer. Following their review of the organizational transfer literature, Cheng and Ho (1998) propose that within a workplace environment, social support is an important influence on transfer of training. This includes leader support, as well as support from all levels within the organizational system (including top management and co-workers). In the context of transfer of training to one's job, support is often conceptualized as the physical and emotional help that a person has available from others. For example, co-worker support could simply involve supporting one's peer to complete an assigned task. Leader support could come in the form of appropriate feedback about their expectations regarding the application of the new knowledge or skill to the job, and/or more formally through performance improvement and management systems. For example, leaders could work with employees to set performance goals that incorporate and encourage the utilization of newly transferred knowledge and/or skills. In this way, social support can help to motivate employees to transfer training to their job. Moreover, support can be manifested in situations that provide people with an opportunity to exercise their newly acquired knowledge and skills (Cheng and Ho, 1998).

Importantly, the potential role of workplace social support and its potential benefits for transfer have been endorsed by other researchers investigating mechanisms of transfer. Research conducted by Tracy et al. (1995) showed the importance of social supports in workplace transfer. The social support system sub-scale of the continuous-learning culture measure exhibited the highest path coefficient, linking it to post-training behaviours and indicating the central role social support plays in transfer of training in the workplace. There is also suggestion in the literature of the importance



of understanding the obstacles to transfer as well as the factors that promote transfer. For example, Baldwin, Ford and Blume (2009) argue that supervisors who oppose transfer can also hinder it.

**Nature of the Task** - A recent meta-analysis (Blume et al., 2010, p. 1067) exploring the factors that influence transfer of training argues that, in general, it is clear that the nature of the task appears to be an important predictor of whether or not transfer will occur. They argue that research

"....has generally supported a generalization gradient in which transfer is more likely with near transfer tasks, which are highly similar to the learning tasks (e.g., working on a small jet engine in training and a larger one in the field), and less likely as one moves to far transfer, in which the tasks and situations in the learning situation are quite different from the transfer setting (e.g., applying principles of electricity from training to troubleshooting complex problems under extreme time pressures; Royer, 1979).

This description of generalization as occurring on a continuum, however, appears to be more anecdotal than experimental. Results of the meta-analysis also showed stronger relationships among predictors and measures of transfer for open skills than for closed skills. The only exception to this rule was that cognitive ability was more associated with transfer in relation to closed skills. However, the sample size of this analysis was quite low. Blume et al. (2010) argue that the open/closed distinction should be made when working to understand transfer.

Although there is clear evidence that complex forms of transfer are very difficult to achieve, there is no available research that seems to directly explore differences in transfer as the result of varying distances from the source to the transfer task, or comparing transfer on open vs. closed skills.

As several researchers have noted, how work environment factors act as mechanisms to facilitate transfer of training initiatives needs to be further investigated. To do this, however, it is necessary to consider more objective measures of work environment on transfer as much of the data gathered derives from self-reports.

#### **Trainee Characteristics**

A large amount of research has also been conducted to understand how various trainee characteristics impact on transfer. Trainee characteristics could impact in a number of ways, including the ability to benefit from the training experience (a necessary antecedent of transfer) as well as affecting motivation to actually use the skills in their actual workplace once training has occurred.

There is strong agreement in the literature that cognitive abilities are a positive predictor of the ability to show transfer (Baldwin, Ford and Blume, 2009). Holladay and Quiñones (2003) defined cognitive ability as the ability to efficiently learn from and reason in one's environment. People with better cognitive abilities are generally assumed to be more proficient at being able to put their knowledge into action in whatever environment is appropriate.

Self-efficacy is also noted in the literature to be an influence on transfer. Self-efficacy can be defined as one's belief about their own ability to organize and execute courses of action required to realize goals (Bandura and Locke, 2003). Self-efficacy is often conceptualized in terms of level (difficulty of tasks one is capable of performing), strength (confidence in attaining a given task) and generality (whether efficacy can be generalized to similar ones). There is some agreement in the literature about the importance of self-efficacy in predicting transfer performance (Baldwin et al., 2009).



The motivation of the individual to learn is also posited as an influence on transfer (e.g., Colquitt et al., 2005). There is some agreement in the literature that trainees' beliefs and expectations play an important role in transfer. For example, Facteau, Dobbins, Russell et al. (1995; cited in Baldwin, Ford and Blume, 2009) argue that trainees must believe that they have the ability to learn, that this learning will improve their performance and that this performance will help them achieve their goals. This analysis speaks to the motivation of trainees as a critical influence on transfer. Baldwin, Ford and Blume (2009, p. 55) argue that "…research on training transfer could be enhanced in the future by considering transfer as a conscious choice that individuals make". Along the same lines, some researchers have argued for combining the more general "motivation to learn" with the more specific "motivation to transfer" (Naquin and Holton, 2002; cited in Baldwin et al., 2009). They call this construct "motivation to improve work through learning" and they argue it to be affected by extraversion, positive affect and work commitment as well as being a better predictor of transfer than training proficiency and generic motivation to learn. Viewing transfer as a process that workers choose to enact, of course, is consistent with the actor-oriented perspectives indicated earlier in this report.

As noted in a recent meta-analysis by Blume et al. (2010), understanding the impact of trainee characteristics on transfer is one of the research areas showing the most progression in recent years. This research explored the relative importance of several trainee characteristics to transfer.

Size of effect	Trainee Characteristics	R with transfer
Moderate	Cognitive ability	.37
	Conscientiousness	.28
	Voluntary participation	.34
Small to moderate	Motivation	.23
	Pre-training self-efficacy	.22
	Neuroticism	

 Table 28. Trainee characteristics influencing transfer (Blume et al., 2010)

This meta-analysis showed that cognitive ability had the strongest relationship with transfer. However, the generalizability of the results for cognitive ability in the meta-analysis may be somewhat limited, as all but 2 of the studies looking at transfer and cognitive ability were conducted in a laboratory setting. Conscientiousness (as measured by personality scales) and voluntary participation also showed moderately strong relationships with transfer. Trainee characteristics showing small to moderate relationships included motivation, self-efficacy and neuroticism (a negative relationship). Smaller correlations were noted for age, education, gender, experience and job involvement.

Next, we explore some examples of research exploring trainee characteristics, and consider some other factors noted in the literature. Ford, Smith, Weissbein, Gully, and Salas (1998) considered the role of trainee characteristics in transfer of training. Specifically, they examined the relationship between trainee characteristics and transfer using a multidimensional perspective that focused on the active role of the learner by integrating design parameters with cognitive processing styles. Ford et al. examined a framework, modeling how individual differences in goal orientation (mastery vs. performance), metacognitive activity (the degree to which an individual is aware of and in control of his or her cognitions), and practice strategies (identical elements and activity level) impacted learning and transfer outcomes. The conceptual model was tested with a sample of



93 undergraduate students who participated in a two-day radar operations study). The training environment allowed trainees to choose their own practice exercises. The model and accompanying regression weights are shown in Figure 18.



# Figure 18. Impact of goal orientation factors and learning strategies on learning and transfer (Ford et al., 1998).

Results from the regression analysis showed support for many of the model predictions. In particular, support was found for a major pathway connecting mastery orientation to metacognitive learning strategies during training. Metacognition was linked to all three learning outcomes (knowledge, training performance, and self-efficacy), which was found to significantly contribute to transfer performance. Results indicate a couple of key findings and implications. First, the significant relationship between all three learning outcomes and transfer performance reinforces the notion that a multidimensional approach to learning outcomes may be optimal. And second, the significant impact of self-efficacy on transfer performance underscores the importance of motivational aspects to transfer of training.

Ford and colleagues (1998) research was novel for because of its multidimensional approach to understanding transfer (i.e., examining how both trainee characteristics and training design factors relate to training outcomes, and how these impact transfer outcomes). Second, Ford et al.'s approach brought into play "cognitive and instructional psychology to identify individual differences and learning strategies and to test how these factors [were] related to learning outcomes and transfer to a more complex task"(p. 219). And finally, the learning environment demanded that the trainee structure their own learning by choosing what types of exercises to practice.

Research by Holladay and Quiñones (2003) simultaneously examined the impact of self-efficacy and general cognitive skills on transfer of training under varying practice conditions (e.g., variable or constant practice). Previous research had shown that random and variable practice can enhance transfer performance (e.g., Schmidt & Bjork, 1992, cited in Holladay & Quiñones, 2003), although the exact nature of this relationship was untested. It was unclear whether practice variability was directly related to transfer of training performance, or whether the relationship was indirectly



affected by another variable. Holladay and Quiñones hypothesized that self-efficacy might mediate this relationship. They also explored the impact of general cognitive skills in this context.

Eighty-two undergraduates participated in a computer simulation that required them to command a U.S. Naval vessel and make judgments regarding targets. The simulation presented nine attributes about the targets that helped participants assess the target's threat level and consequently, to decide on the best defensive position for them to take (i.e., ignore, monitor, warn, ready, defend). Participants began by taking part in a practice session. Participants in the constant condition received training with three attributes of the target changing, and six attributes fixed. Participants in the variable practice condition received two types of training (a) three attributes changing, six attributes fixed and (b) six attributes changing, three attributes fixed. Participants were told that they would earn points for the quality of their task performance. Participants in both conditions practiced the computer task for a total of 48 trials. After the training session, self-efficacy was measured. Participants were asked to predict the number of points they would earn by their task performance, and to rate their confidence in achieving those predictions. Self-efficacy generality was calculated as an outcome of the variance of self-efficacy level and the variance of self-efficacy strength. According to Holladay and Quinones, a small combined variance meant participants held similar self-efficacy beliefs across task variations, suggesting greater self-efficacy generalization. On the other hand, a large variance meant participants held more diverse self-efficacy beliefs, suggesting less generalization across situations and tasks.

Following measurement of self-efficacy, participants went through the transfer session. This session was similar to the training session and included 30 trials. Ten of these trials were identical to the constant condition, and the last 20 trials varied 5 or 8 attributes. <u>Transfer</u> was measured by calculating the average number of points in the trials that were identical in the training and transfer sessions (i.e., 10 trials with 3 attributes changing). Similarly, <u>transfer</u> was measured by calculating the average number of points in the trials that were not practiced in the training session (i.e., 20 trials with 5 and 8 attributes changing). Performance in the training session and in the transfer session was measured using the same method. Participant's accuracy of their judgement regarding the threat of the target was given 5 possible points based on the outcomes. Specifically, the difference between the participant's judgement and the actual outcome was measured according to a point system. A hit was awarded 2 points, a near miss was 1 point, a miss was 0 points, an incident was -1 point, and a disaster was -2 points. For example, a near miss was given if a participant decided to ignore a target instead of monitoring it.

Results of Holladay and Quiñones' (2003) study showed that participants in the variable condition held more stable views of self-efficacy than participants in the constant condition. In other words, participants who were trained with changing elements had similar predictions for the number of points they would receive and stable confidence levels throughout the transfer session. These participants also showed higher self-efficacy generality than participants in the constant condition. Participants who were trained with changing elements showed a greater generalization between tasks.

The cognitive skills of participants also played a role in transfer. Controlling for cognitive abilities showed an intriguing emerging pattern, one that differentiated participants across the four conditions of the study. Specifically, participants with low cognitive ability showed lower performance on the transfer task than did participants with high cognitive ability. Interestingly, low cognitive ability participants trained in varying elements showed similar performance to high cognitive ability participants under the same training conditions. Stated another way, low cognitive ability participants performed poorly when training and transfer tasks differed, but only under



constant training conditions. One might attribute this finding to participants with high intelligence having superior analogical reasoning abilities (i.e., encoding, inference, mapping, application, and response). This would allow these trainees to enact general strategies required by the transfer task more readily than those with lower intelligence (who may be required to reveal the general strategy or pattern). If the goal is to facilitate transfer, this research suggests that despite cognitive ability, the ideal method of training (in a simulation context) may be to alter task elements during the training session, rather than maintaining consistency. Changing the task elements may reduce the influence of cognitive ability on the ability to transfer.

Other results showed evidence for transfer of training for both types of training conditions. Specifically, <u>transfer</u> was more prevalent when the training conditions varied between 3 and 6 attributes (i.e., variable). On the other hand, <u>transfer</u> effects were evident for participants who received training in the constant condition (i.e., three attributes changing, six attributes fixed). In other words, when the elements of their training tasks were varied, participants performed better on tasks that were different from the original training conditions. Participants also performed better on tasks that were similar to those they experienced during training when the elements did not vary. Holladay and Quiñones concluded that self-efficacy mediates the relationship between training variability and complex transfer performance.

Holladay & Quiñones, 2	2003
Methodology Used	Instructional training on computer task
Source/Cue/Training	Computer target training
Probe/Test/Outcome	Performance on computer task
Independent Variables	Target training (constant attributes or variable attributes)
Dependent Measures	Self-efficacy (predicting points and confidence), transfer performance, and cognitive skills
Findings	Training with changing elements resulted in higher generalization across tasks and more stable self-efficacy. High cognitively able participants showed more generalization across tasks, except when low cognitively able participants were trained with changing elements

Table 29	. Holliday	and	Quinones	(2003)
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There is some evidence in the literature that <u>expertise</u> can influence transfer of training. The literature accessed for this review suggests that experts seem to be more adept at analogical transfer than non-experiments, presumably because they are better able to encode information such that it can be retrieved more easily (Gentner et al, 2009). This way of thinking about analogical reasoning is consistent with a "mental models" account of cognition, wherein experts are commonly argued to be more adept at creating more structurally complex models.

Lastly, it is also important to note another factor noted in the literature as being important to transfer of training, namely the opportunity to <u>use</u> the skills gained during training in real-world settings (e.g., Blume et al., 2010; Quinones, 1995; cited by Cheng & Hampson, 2008). If skills taught are not used, they may quickly fade away. This influence, however, may interact with other trainee characteristics, such as motivation to transfer the skill.



## Discussion

This chapter reviewed research showing several sets of factors that influence transfer. These include the role of training design in transfer. For example, some research found that diverse case-training as opposed to specific case-training facilitates transfer and generalization across varying contexts (Moran et al., 2008), and that transfer was even better when receiving feedback from instructors during training (Ansburg & Shields, 2003). Other research by Bell and Kozlowski (2008) picks up on a persistent theme within the transfer literature; namely, the value of active learning in working to ensure high levels of transfer. Goettl and Shute (1996) found that critical part-task training was as effective as whole task training, and was particularly helpful for people with lower abilities. Other research has shown that whole-task training is often more effective than part-task training at facilitating transfer. This may be because the former promotes rich schema development, which helps people transfer their acquired knowledge and skills more generally (Lim et al., 2009). Again, this area of research is rife with conflicting and inconsistent findings.

Work environment factors like organizational climate and continuous-learning culture as well as social supports also contribute to transfer of training (Tracey et al., 1995). Among these, the most empirically established influences (on the basis of a recent meta-analysis) appear to be transfer climate and supervisor support. Characteristics of the trainee have also been shown to influence transfer of training. Most prominent among these is cognitive ability, with other factors such as self-efficacy and motivation also playing an important role (Ford et al., 1998; Holladay & Quiñones, 2003).

The theoretical constructs of research exploring transfer of training within this section has clear overlap with the analogical reasoning research. Specifically, as in analogical reasoning research, the research reviewed in this section also emphasizes the importance of using principles when training for maximal transfer and shows that the initiation of comparison processes is an important contributor to transfer.

One of the notable problems in working to make connections between the two different streams of literature (transfer as a cognitive process and the transfer of training literature) is that they have developed in relative isolation, and seem to be continually separate. For example, even a recent 2009 update of the transfer of training literature focused only on articles cited the Baldwin and Ford 1988 article. This narrow focus may unnecessarily constrain the views of transfer that are perpetuated within this broad body of research.

It is also important to note a potentially serious limitation of the broader transfer of training research reviewed in this section (and evident in the literature as a whole). This limitation is important to highlight, because it makes the outcome of existing research more difficult to interpret. Blume et al. (2010) indicate that inconsistent measurement has been a persistent problem for transfer researchers. Specifically, they argue that 3 measurement-related issues have plagued this area. These include long time lags between training and transfer measures, the failure to adequately account for the distinction between open skills (that allow latitude and creativity) and closed skills (that must be completed in a prescribed way) and the high degree of reliance on self-report measures.

A very recent review by Blume et al. (2010) showed compelling evidence about the potential impact of common method variance when attempting to measure transfer. After exploring a range of possible studies to include within their meta-analysis (many of which used similar methods to explore a range of dimensions relevant to transfer), they were able to estimate the degree of single-



source and same-measurement-context (SS/SMC) bias. They were then able to more accurately show the strength of the predictor-transfer relationships after controlling for this bias.

Importantly, when predictor variables and transfer were measured at the same time, the correlation for the relationship between the environment and transfer in studies with SS/SMC bias was .54, but only .23 in studies without bias. Moreover, effect sizes also jumped from .23 to .36 when 13 studies with SS/SMC bias were included in the effect size calculations for this pairing. Similarly, in studies with motivation as a construct, the correlation between motivation and transfer was .41 in studies with bias and .23 in studies without. This shows that SS/SMC biases inflated correlations among predictors and transfer dimensions as well as some effect sizes.

This important research shows that interpreting the existing literature (purported to show transfer) may be problematic. From the perspective of attempting to understand transfer within teams, it shows the importance of using multiple measures in varying contexts. Given the previous models of transfer and the importance of the characteristics and perceptions of the individual (e.g., perceived self-efficacy and motivation), however, reliance on some self-report measures may be necessary. To the extent possible, even if subjective measures must be used, using as many objective measures as possible would also be ideal.



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Understanding how best to train CF personnel to work effectively in teams, and how maximize their ability to use their training within new and unexpected situations is a critical requirement. This report examines the transfer literature in the psychology and team domain in order to identify the factors most likely to influence transfer performance. Research relevant to two overlapping areas of research is reviewed in this report.

First, cognitive psychological research exploring analogical reasoning casts transfer primarily as a cognitive process involving analogical reasoning, and includes encoding, inference, mapping, application and response. Established researchers in this area suggest that analogical transfer can be very powerful when it occurs, but transfer can also be a very elusive event.

The second line of research explored team transfer and team adaptation research. Team adaptation is defined as a change team performance as the result of a salient cue that leads to some sort of response. Team adaptation could result in new structures or the modification of existing structures, abilities, and/or behaviours or cognitions directed at specific goals. This formation or manipulation of existing structures within a task (such as a cognitive schema or inter-member communication) improves how the team operates and/or achieves objectives. However, this area of research is particularly underdeveloped in the link to the most critical form of transfer in real-world environments, transfer in more complex environments and more difficult tasks.

Nonetheless, the studies reviewed provide a number of insights about the nature of transfer within teams. They show the importance of comparison processes as a positive influence on all forms of transfer (analogical, workplace and within the team context). Although comparison of stimuli and situations is relevant in the team literature, another particularly important form of comparison within a team context is comparison of one's own roles and responsibilities to those of other teammates. There is also good evidence that the transfer of the strategies learned and/or knowledge gained in this comparison process is facilitated by the emergence of a more unified body of knowledge (i.e., a mental model) that serves as an analogy, allowing the transfer of strategies and skills to a new situation to be more effective. Overall, the literature reviewed suggested that people working to understand or promote transfer should consider multiple transfer strategies in combination. From a pragmatic perspective, this means that the design of training, the complex environment within which training occurs, and characteristics of the individual will all need to be necessary parts of CF trainers' efforts to promote transfer within CF teams.

Il est essentiel de trouver la meilleure manière d'enseigner aux militaires comment travailler efficacement en équipe et mettre en pratique ce qu'ils ont appris dans des situations nouvelles et imprévues. Dans le présent rapport, nous tentons de découvrir les facteurs les plus susceptibles d'influencer l'efficacité du transfert de formation à partir des ouvrages que nous avons consultés dans les domaines de la psychologie et du travail d'équipe. Nous nous penchons en outre sur des études menées dans deux domaines de recherche qui se chevauchent.

D'abord, nous nous sommes intéressés à la recherche menée dans le domaine de la psychologie cognitive sur le raisonnement analogique. Sous cet aspect, le transfert de formation est considéré surtout comme un processus cognitif faisant appel au raisonnement analogique, qui comprend l'encodage, les inférences, la mise en correspondance, la mise en application et la réponse. Selon des chercheurs reconnus dans ce domaine, le transfert analogique peut être un processus très efficace, mais il peut aussi être difficile à cerner.

Dans un deuxième temps, nous avons étudié les recherches en matière d'adaptation et de transfert collectifs. L'adaptation collective se définit comme une modification du rendement d'une équipe résultant d'une circonstance évidente suscitant une réaction quelconque. L'adaptation collective peut provoquer la création de nouvelles structures ou la modification de structures, habiletés, comportements ou connaissances déjà en place dans le but d'atteindre des objectifs précis. La formation de structures ou la manipulation de structures déjà en place à une fin précise (par exemple, établissement d'un schéma cognitif ou d'une structure de communication intraorganisationnelle) augmente l'efficacité d'une équipe et l'aide à atteindre les objectifs qu'elle s'est fixés. Ce domaine de recherche demeure toutefois peu

exploré, surtout en ce qui concerne la plus importante forme de transfert, soit celle qui vise à appliquer les connaissances acquises à des situations réelles afin de résoudre des problèmes plus complexes. Néanmoins, les études sur lesquelles nous nous sommes penchés offrent un aperçu de la façon dont se passe le transfert d'acquis de formation au sein d'une équipe. Elles montrent l'importance des processus de comparaison et de leurs effets positifs sur tous les types de transfert (analogique, en milieu de travail et au sein d'une équipe). Bien que la comparaison des stimuli et des situations soit un aspect pertinent dans le domaine du transfert collectif, la comparaison des responsabilités entre les membres d'une équipe revêt également une importance particulière. Ce type de comparaison est au cœur de nombreuses formes de formation collective. De plus, tout porte à croire que le transfert des stratégies et des connaissances acquises durant le processus de comparaison est facilité par l'émergence d'un ensemble de connaissances plus uniforme (c.-à.-d., un schème de pensée) permettant l'expression d'une analogie et, par le fait même, l'adaptation de stratégies et de connaissances à une nouvelle situation de manière à accroître l'efficacité collective.

Dans l'ensemble, les ouvrages consultés indiquent que les gens souhaitant mieux comprendre ou favoriser le transfert d'acquis devraient envisager d'avoir recours à différentes stratégies à la fois. D'un point de vue pragmatique, cela implique que les instructeurs des FC devront tenir compte de la conception de la formation elle-même, de la complexité de l'environnement dans lequel la formation est donnée ainsi que des caractéristiques individuelles des personnes concernées afin de maximiser l'efficacité du transfert des acquis de formation au sein de leurs équipes.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

transfer of training; anaological transfer; team adaptation; learning; training; cognition; teams; problem solving